NISI · DOMINUS · ÆDIFICAVERIT · DOMUM

MODERN HOUSE CONSTRUCTION

THE PRINCIPLES AND PRACTICE OF

MODERN HOUSE-CONSTRUCTION

INCLUDING

WATER-SUPPLY AND FITTINGS—SANITARY FITTINGS AND PLUMBING—DRAINAGE AND SEWAGE-DISPOSAL—WARMING VENTILATION—LIGHTING—SANITARY ASPECTS OF FURNITURE AND DECORATION—CLIMATE AND SITUATION STABLES—SANITARY LAW, &c.

EDITED BY

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AUTHOR OF "CONCRETE: ITS NATURE AND USES", ETC.

The proper construction of houses is a matter of vital interest to every individual and to the community at large. Houses badly-designed and jerry-built are sure and costly sources of discomfort, disease, and death. Damp rises in the walls or rain drives through them; dank smells pervade the rooms, while dry-rot spreads its noisome mantle in the close space beneath; chimneys smoke; windows rattle; the roof leaks; frost fast binds the water and bursts the pipes; drains are choked, and the sewage oozes through the open joints into the pervious soil, possibly to pollute the water-supply, while the foul odours and gases generated in the drains and sewers pass, by untrapped waste-pipes, into the house. Hence come many diseases, as rheumatism, diphtheria, fevers, &c.

Many books have been written on the several portions of the great science of sanitary house-construction—particularly respecting plumbers' work and drainage—but few have attempted to deal comprehensively with the whole subject, and fewer still have treated the subject in a thoroughly practical manner. Sanitary science, moreover, is a progressive science, and early books on the subject are now almost entirely out of date. New materials have been introduced, or old materials have been adapted to new purposes, as in the case of iron drains. New discoveries have been made, especially in reference to sewage-purification by micro-organisms, and to the spread of disease by germs in air, food, and water. And new appliances have been invented, foremost of which are those for the reception and removal of household refuse in all its forms.

This book is an attempt to describe the new materials and the new uses of old materials, to set forth the new discoveries and their issues in practical work, and to illustrate those new appliances which appear to be valuable and useful. Each portion of the book has been written by a specialist in his own particular branch of the subject, the contributors including five Architects, four Civil Engineers, three Doctors of Medicine, one Electrical Engineer, one Gas Engineer, one Barrister and Medical Officer of Health, one Sanitary Inspector, and one Plumber; and the whole work has been carefully edited by G. Lister Sutcliffe, A.R.I.B.A., M.San.I., a practising architect.

Seventeen writers have contributed to the work, all being men whose names are familiar in the realms of architecture, civil engineering, medicine, and sanitary science,—many being well known as the authors of books, papers, &c., and as contributors to technical journals, and all having practical knowledge of the subjects of which they treat.

In consequence of this specialization the information given in the book will, it is anticipated, prove to be not only accurate but thorough and up-to-date, and therefore invaluable to professional men of all classes engaged in house-construction or house-inspection, including Architects, Civil Engineers, Sanitary Engineers, Doctors, Medical Officers of Health, Sanitary Inspectors, Clerks of Works, Building Inspectors, &c. Teachers of Hygiene, Sanitary Science, Building Construction, &c., will find the book full of useful and important information, while the ambitious student cannot afford to be without it.

The work is intended, however, not solely for professional men and students, but is designed also to educate and assist all those—be they masters or workmen—who are actually engaged in the various operations of building, and whose aim is to produce the best work possible in their respective trades, including plumbers, gas-fitters, hot-water engineers, bricklayers, slaters, joiners and builders, drain-layers, &c. Here they will find information regarding the best and latest methods and appliances. Illustrations and descriptions of all important details of house-construction are given, including masonry, bricklaying, slating and tiling, wood-work, water-supply, drainage, plumbing, warming and ventilation, gas-fitting, electric-lighting, &c. &c.

The scope and merits of the work will be more clearly realized from the following list of the Sections into which it is divided, and from the names of the Authors appended thereto:—

LIST OF SECTIONS AND AUTHORS.

	General Introduction,	F. W. ANDREWES, M.D., F.R.C.P., D.P.H.
Section I.	Plan,	Prof. ROBERT KERR, F.R.I.B.A.
„ II.	Construction,	G. LISTER SUTCLIFFE, A.R.I.B.A., M.San.I.
„ III.	Water-Supply,	HENRY LAW, M.Inst.C.E., F.San.I.
„ IV.	Domestic Water-Supply,	HENRY CLAY.
„ V.	Household Filters,	H. JOSSÉ JOHNSON, M.B., D.P.H.
„ VI.	Sanitary Plumbing,	HENRY CLAY.
„ VII.	Sanitary Fittings,	KEITH D. YOUNG, F.R.I.B.A.
„ VIII.	Drainage,	WILLIAM SPINKS, A.M.Inst.C.E.
„ IX.	Sewage-Disposal,	H. PERCY BOULNOIS, M.Inst.C.E., F.San.I.
„ X.	Warming,	E. R. DOLBY, A.M.Inst.C.E., M.I.M.E.
„ XI.	Warming and Cooking by Electricity,	E. A. CLAREMONT, M.I.E.E., M.I.M.E.
„ XII.	Ventilation,	WILLIAM HENMAN, F.R.I.B.A.
„ XIII.	Lighting, 1. *Candles, Oil, and Electricity*,	E. A. CLAREMONT, M.I.E.E., M.I.M.E.
	2. *Gas*,	HENRY CLAY.
„ XIV.	Gas-producing Apparatus,	J. MURRAY SOMERVILLE.
„ XV.	Furniture and Decoration,	E. F. WILLOUGHBY, M.D., D.P.H.
„ XVI.	Sanitary Inspection of Houses,	WILLIAM H. WELLS.
„ XVII.	Improvement of existing Houses,	G. LISTER SUTCLIFFE, A.R.I.B.A., M.San.I.
„ XVIII.	Climate and Situation,	E. F. WILLOUGHBY, M.D., D.P.H.
„ XIX.	Stables,	F. W. LOCKWOOD, F.I.S.E.
„ XX.	Sanitary Law,	A. WYNTER BLYTH, M.R.C.S., F.I.C.

During the past fifty years much has been accomplished in the field of **sanitary reform**, but much still remains to be done. We have gained accurate knowledge, based on exact observation and statistical research, of the nature of many diseases and the modes in which they are spread; and, speaking broadly, it may be said that the sanitary advances of the Victorian age have consisted in the removal of the predisposing conditions of disease. Even now, however, it cannot be said that the general principles of sanitary house-construction are adequately understood by householders, or even by those actually engaged in the design and construction of dwellings. It is hoped that this book on the "Principles and Practice of Modern House-Construction" will be of service in furthering the great work of sanitary improvement.

To Councillors, and Members of Sanitary Authorities, the book cannot fail to be of service, upholding as it does a high standard of building and sanitary work, which, if maintained in practice, will inevitably result in the reduction of disease and death. Of all men in the community, those who are set in authority ought to have clear and correct ideas on this important subject of house construction.

The illustrations form a most important feature of the work, being upwards of 700 in number, and covering practically the whole range of house-construction from foundation to roof, from sanitary fittings and water-supply to sewage-disposal, and including numerous illustrations relating to lighting, warming, ventilation, &c. Wherever necessary, separately printed plates have been introduced to illustrate important details, several being printed in colours, and some being of larger size and made to fold, numbering in all about twenty-four.

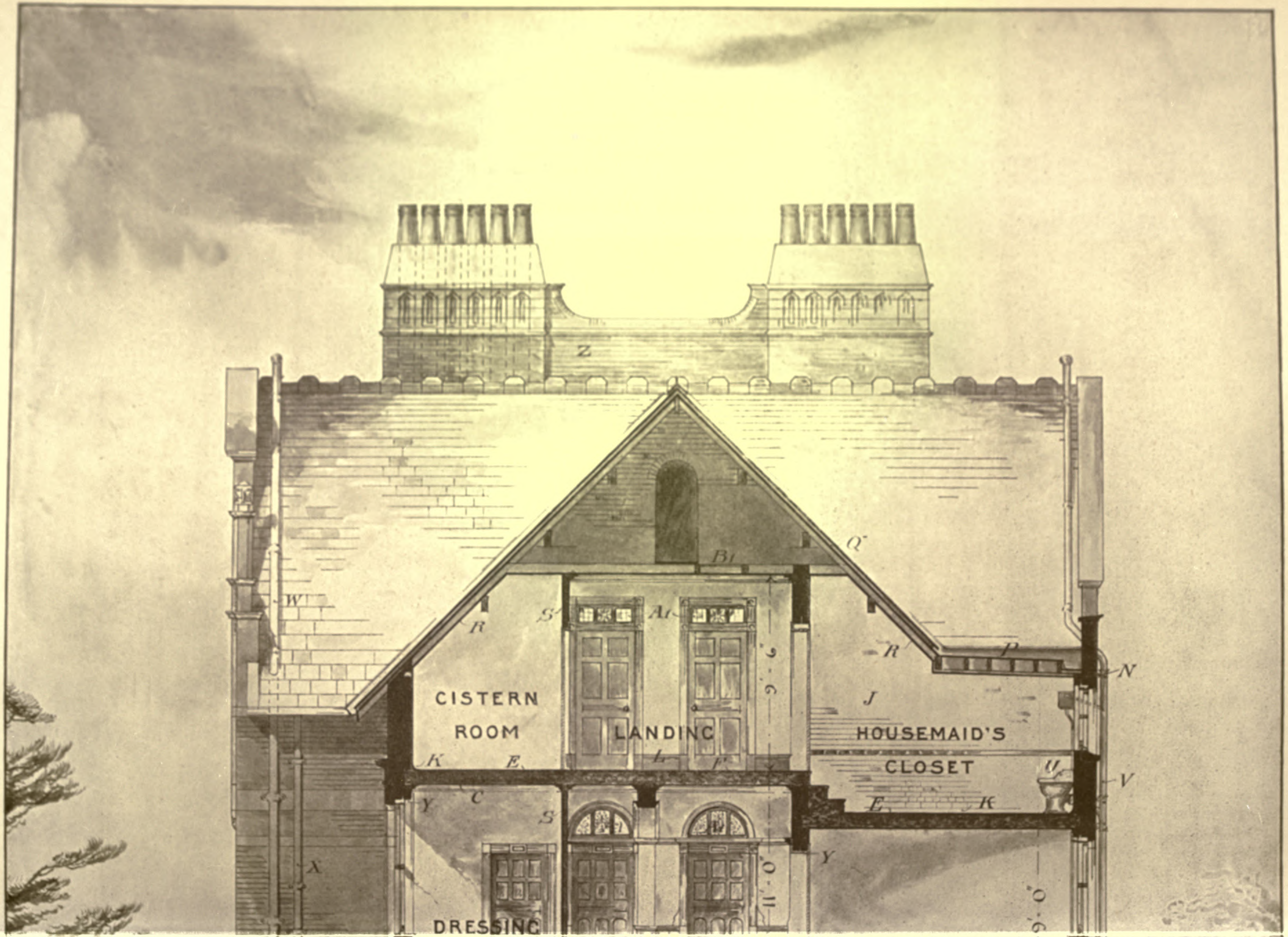
A very full index will render the whole information contained in the book easy of reference.

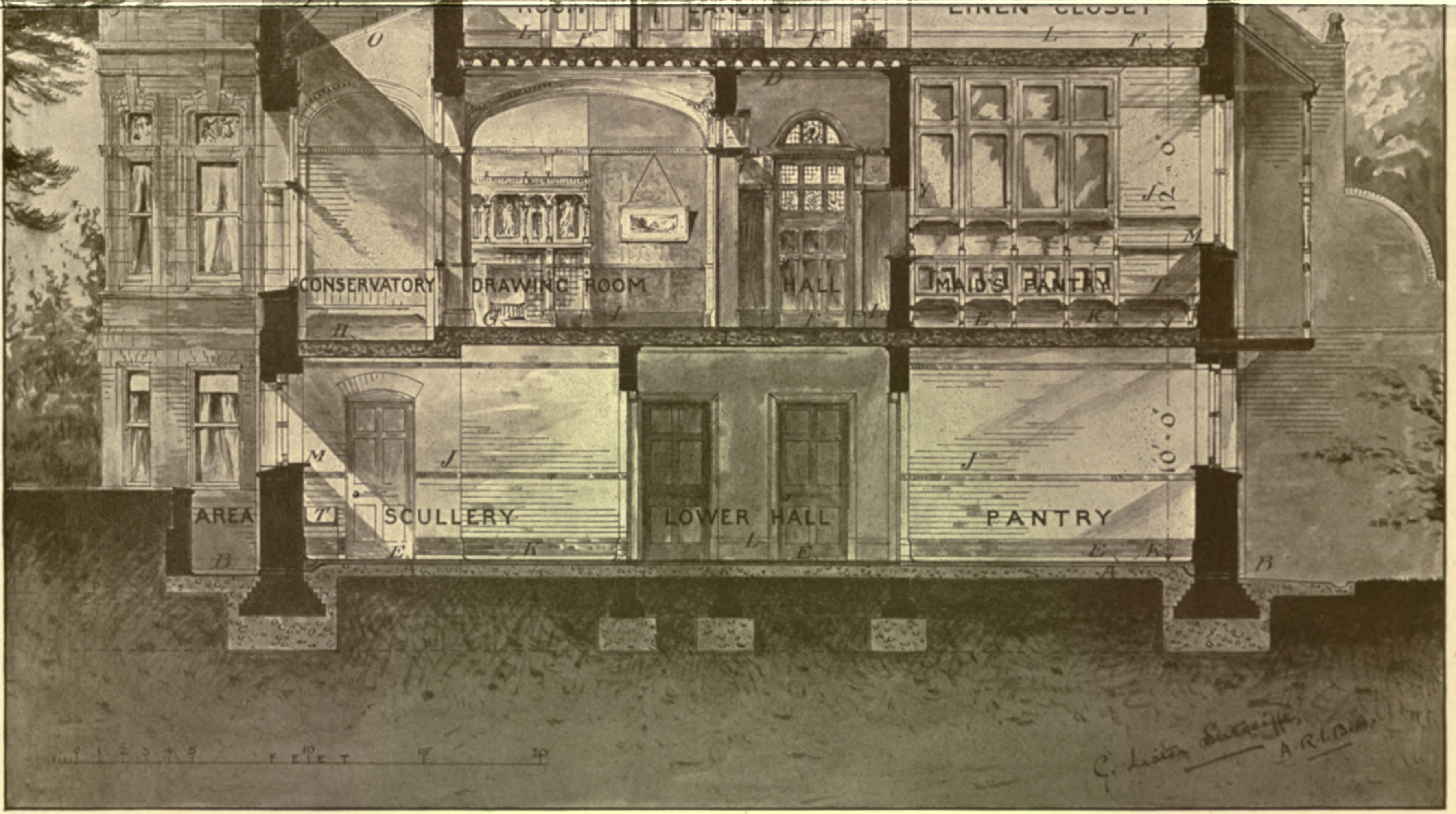
Conditions of Publication. The work will be printed on fine paper, demy 4to size, and will be issued in 6 divisions, strongly bound in cloth, at 8s. each. No order will be accepted except for the entire work.

THE PRINCIPLES AND PRACTICE

OF

MODERN HOUSE-CONSTRUCTION


CISTERN ROOM
LANDING
HOUSEMAID'S CLOSET
DRESSING



SECTION THROUGH SUBURBAN HOUSE.

A. Concrete ground-layer, 6″ thick.
B. Asphalt damp-course extending over walls, ground-layer, and area.
C. Concrete floors.
D. Fawcett's fire-proof flooring, consisting of tubular earthenware lintels, steel joists, and concrete.
E. Terrazzo floor-surfaces.
F. Wood-block flooring.
G. Parquet flooring.
H. Tiled flooring.
I. Tiled dado.
J. Glazed brickwork.
K. Curve formed in terrazzo or cement.
L. Cement skirting.
M. Slate window-ledges.
N. Asphalt damp-course under parapet and gutter.
O. Glazed roof (the roof of balcony also to be glazed above all windows).
P. Lead flat.
Q. Roof formed with boards, felt or Willesden paper, raking and horizontal laths, and Westmoreland slates.
R. Laths and plaster.
S. Concrete-slab partitions.
T. Sinks.
U. Slop-sink with cistern over.
V. Waste-pipe from slop-sink and ventilating-pipe for back-drains.
W. Ventilating-pipe for front-drains.
X. Rain-water pipe.
Y. L-shaped steel lintels.
Z. Party-wall carried above roof.
A 1. Door fanlights made to open.
B 1. Manhole for access to loft.

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ILLUSTRATED BY ABOVE 700 FIGURES IN THE TEXT, AND A SERIES OF SEPARATELY-PRINTED PLATES

DIVISIONAL-VOL. I.

BLACKIE & SON, LIMITED
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PREFATORY NOTE.

DIVISIONAL-VOL. I.

"Houses are built to live in, and not to look on", as the philosopher Bacon pithily says, and his aphorism may fitly be appropriated as the motto of the present work. Beauty, symmetry, the fair things that please the eye, are in truth contributors to the joys of life; but life itself must ever claim priority. All then that concerns the design and construction of houses in relation to the health and comfort of their occupants forms the subject of this practical work.

The work is divided into sections, each of which is written by a specialist in his particular branch. The reader may therefore be assured that the work embodies the best results of individual study and experience, at the same time that it contains, in due order and arranged for easy reference, all the wide-ranging information he may require.

Each contributor is responsible for the section in which his name appears, and for that alone. Where the editor has thought it necessary to call attention to points on which there may be a reasonable difference of opinion, he has done so by means of foot-notes.

With regard to the illustrations in Divisional-Volume I., indebtedness has to be acknowledged to the following firms:—Messrs. Banks's Fireproof Construction Syndicate, Ltd., London; Broomhall Tile and Brick Co., London; Joseph Cliff & Sons, Wortley, near Leeds; Doulton & Co., Lambeth; J. C. Edwards, Ruabon; Mark Fawcett & Co., London; Geo. Gunton, Costessy, Norwich; Crosby Lockwood & Son, London; N. A. P. Window Co., Ltd., London; Noyes & Co., London; Rowlands Castle Brick & Tile Co., Rowlands Castle, Hants.

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SECTION I.—PLAN.

BY PROFESSOR ROBERT KERR, F.R.I.B.A.

SECTION II.—CONSTRUCTION.

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DIVISIONAL-VOL. I.

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GENERAL INTRODUCTION

BY

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GENERAL INTRODUCTION.

CHAPTER I.

HISTORICAL.

It is a law of nature that those races of animals which fail to adapt themselves to their surroundings are doomed to perish. Man, however, has learned to adapt his surroundings to himself, whereby he is enabled to live in large measure independently of climate and adverse physical conditions. **Sanitary Science** is the body of facts and rules which teach the art of living under those external conditions which best promote health and length of days. No part of sanitary science is, in our climate at least, more important than that which is to be dealt with in this work—the part which treats of the proper construction of the houses in which we are compelled to spend the greater part of our time.

As an exact science, sanitation is of quite modern growth, yet its beginnings are of remote antiquity. While men lived a purely nomadic life, sanitary requirements may have been almost non-existent; as soon, however, as men came to live together in settled communities, regulations became necessary, and they have gradually acquired importance in direct proportion to the size of towns and the density of population. The earliest rudiments of sanitary law may be traced in the Pentateuch, and Layard has shown that there was a system of drainage in the palace at Nineveh. We know from the writings of the ancients, and from what remains to this day, that ancient Rome possessed a municipal public-health system, with public medical officers, and marvellous works for water-supply and drainage.

With the decay of ancient civilization, sanitation lapsed into a deplorable condition for many centuries. The havoc wrought by plague and pestilence ultimately terrorized men into some attempts at sanitary improvement even during the Middle Ages. In England the commencements of sanitary regulations are to be traced in the thirteenth century, and three centuries later we find definite attempts to restrict overcrowding in London, and to improve the system of sewers. The great fire of 1666 gave to London the opportunity for reconstruction on better principles, but a false economy and prevailing ignorance prevented more than partial use being made of it. The Rebuilding Acts of Charles II. did, however, secure wider streets, walls and party walls of brick or stone, and certain standards as to the height of stories and similar matters, while special surveyors were appointed to see that the new regulations were properly carried out.

An adequate system of sanitary science requires, as its basis, a knowledge of the nature and causation of disease, and of the conditions which foster its spread. So long as men were content to accept pestilences and death as visitations of God, to be endured with Christian fortitude and resignation, no great advance was possible. But with the growth of medical knowledge arose the idea of the preventibility of much of the disease from which mankind suffered; and the gradual spread of this idea may be traced throughout the eighteenth century, owing largely to the writings of Mead, Pringle, Lind, Howard, and other pioneers in sanitation. Yet it took a century for the idea to ripen and bear fruit, and when Queen Victoria ascended the throne, there was still to all intents and purposes no sanitary legislation. Doctors there were in plenty, and abundant experience to illustrate the truths that overcrowding, bad food, foul air, damp houses, and accumulations of filth, are fertile causes of disease and death, but the duty of effective action was not yet realized by the State, and as the State alone could take such action, practically nothing was done. Local and Central Boards of Health were indeed established in the reign of William IV., and upon them devolved certain duties of inspection and advice: in the last year of his reign, too, the Act for the Registration of Births, Marriages, and Deaths was passed. This act first made statistics of health possible, and it is such statistics that have driven home the facts of sanitary science into the public mind and conscience.

It is impossible to recount here the detailed **growth of sanitary reform** during the reign of Victoria, but it is possible to indicate some of the chief steps. We have gained accurate knowledge of the nature of many diseases and the modes in which they spread—a knowledge based on exact observation and statistical research. Public opinion has been awakened and educated, and is now fully alive to the importance of hygienic requirements. The State has realized its responsibilities, and we have a sound body of sanitary legislation, not perfect indeed, but comprehensive and workable; we have central and local bodies responsible for the due carrying out of the law, and in every district in the country we have a qualified medical officer of health charged with the sanitary welfare of his community. The State has, in short, taken medicine into its service, and avails itself of expert advice on sanitary matters.

In most preventible diseases there is an actual direct cause and various predisposing causes. Thus we have learned in the last decade or so that consumption depends upon a specific cause—the tubercle bacillus—but we knew, long before, that damp, overcrowding, and lack of ventilation were conditions predisposing to the disease, and it has now been proved that due attention to these matters largely reduces the mortality from it. Still more recently we have learned that cholera is due to a specific comma-bacillus, but we already knew that filth, squalor, and a foul water-supply were the main factors which promoted epidemics of the disease, and by obviating these defects we have removed its chief terrors. Speaking broadly, it is in the removal of the predisposing conditions of disease that the great sanitary advances of the last half-century have consisted. Nevertheless the hands of the reformer have been greatly strengthened by the exact knowledge which bacteriology has afforded as to the intimate nature of the actual causes of infectious disease.

Two names deserve honourable and special mention in connection with sanitary reform during the present reign—those of Sir Edwin Chadwick and Sir John Simon.[1] Chadwick's name will be ever associated with the general inquiry (extending from 1839 to 1842) into the sanitary condition of the people —an inquiry which revealed the enormous part played by insanitary conditions in diminishing the health and wealth of the nation, and which resulted in valuable reforms being suggested in all directions. A Royal Commission was appointed, and the ultimate result was, among other Acts, the **Public Health Act of 1848.** A new executive department was created—the General Board of Health, which was the sanctioning authority for the various objects which local ratepayers and boards might desire under the Act, and which framed by-laws and instructional minutes, and was energetic in its attempts to popularize district cleanliness. The character of the Board was altered in 1854, and medical inspectors were appointed; and in the following year John Simon, who had been Medical Officer of Health to the city of London since 1848, was made permanent Central Medical Officer: his name became thenceforth identified with the cause of sanitary improvements.

A new Public Health Act was passed in 1858, but the Act of 1866 began the era in which local Sanitary Authorities were compelled to take action whether they would or no, and which gave powers to all districts for the

[1] The writer has to acknowledge the great assistance which he has derived from the writings of Sir John Simon in drawing up this historical sketch.

provision of a proper water-supply, provided for the sanitary regulation of the tenement-houses of the poor, and endeavoured to put down overcrowding, and unwholesomeness of places of labour. In 1871 the **Local Government Board** was created, and became the central controlling sanitary authority. Medical Officers of Health were made compulsory for every district in 1872, and the qualifications for such a post were raised in 1888. The great consolidating **Public Health Act (1875)** marks a great step in advance as amending the patchwork condition into which the law had got, and within a few years a number of other important sanitary acts were passed. The chief among them were the Sale of Food and Drugs Act (1875); the Rivers Pollution Prevention Act (1876); the Consolidating Factory and Workshop Act (1878); the Artisans' Dwellings Improvement Acts (1875–82); the Notification of Infectious Diseases Act (1889); the Housing of the Working Classes Acts (1885–90), dealing with unhealthy areas and dwellings, and with obstructive buildings; the Public Health (London) Act (1891), which did for the metropolis what the 1875 Act had done for the rest of the country; and, most recently, the Factory and Workshop Act of 1895.

Improvements which have been effected.—It is thus abundantly evident that there has been a steadily increasing activity in the progress of sanitary legislation. Let us now consider what principles have become recognized, and what are the chief sanitary improvements which have been effected or attempted.

1. *Pure-Water Supply.*—It is universally recognized that an abundant supply of pure and wholesome water is a necessity of health. The provision of an adequate water-supply in towns is one of the most important duties of sanitary authorities, and even in the country the authorities must see that every occupied dwelling-house in the district has a sufficient and good supply within reasonable distance: they have powers to compel the provision of such where it can be done at a reasonable expense. In London an occupied house without a proper and sufficient supply of water constitutes a nuisance, and is deemed unfit for human habitation. Moreover, the standard of what constitutes a pure-water supply is tending upwards, and it is becoming recognized that chemical analysis alone is not always a sufficient test of purity. Bacteriological analysis is coming into more frequent use, and it is likely that a strict bacteriological control of water-supplies would prove an important aid in checking the spread of disease. Koch even suggests as a standard that all filtered water containing more than a hundred microbes per cubic centimetre be discarded, but no such stringent rule is at present dreamed of in this country. The new Berlin

water-supply, which is subject to strict bacteriological control, shows, as a rule, less than fifty microbes per cubic centimetre. The construction and action of filtering beds is becoming better understood, and the importance of efficient filtration is well recognized.

2. *Improved Sewerage.*—Improved systems of sewerage are to be accounted amongst the chief sanitary improvements of the past half-century. Much is due in this respect to the labours of Chadwick, who first insisted that town refuse should be removed by the scour of running water in sewers and earthenware pipes so designed and laid as to be self-cleansing. Simon considers the glazed earthenware pipe, as applied to drainage, the most valuable sanitary contrivance devised since the time of the Romans. It is clearly recognized that too great importance cannot be attached to the speedy and complete removal of all excreta and putrescible waste matters from dwelling-houses, and the ingenuity of architects and engineers has been taxed to attain this end without permitting the escape of sewer-gas into the house. It may be said that this has been attained in no small measure, and that in many of our towns the construction of the sewerage systems on modern lines has realized the dreams of Chadwick in a very successful manner. The principles which are commonly taught and accepted in sewer and drain construction include the use of impermeable materials, the employment of adequate gradients with channels of proper size (neither too large nor too small), and the adoption of efficient flushing and ventilation. A Sanitary Authority is bound to require householders or owners to provide proper drains.

3. *Scavenging.*—Scarcely less important is the removal from dwelling-houses of such solid waste matters as cannot be got rid of by the drains—the dry refuse of the house. Sanitary authorities may, and when required by the Local Government Board *must* undertake scavenging duties, or contract for their efficient performance, imposing by by-law upon householders certain duties in connection therewith. Accumulations of refuse constitute a nuisance to be dealt with summarily.

4. *Improved Construction of Dwellings.*—In the matter of dwelling-houses, with which this book is more particularly concerned, very great changes and improvements have been effected. We have learned from experience and from a study of mortality statistics, the fundamental principles which underlie healthy house-construction. It is recognized that, in towns, streets must be wide and airy, the buildings not too high in proportion to the width of the streets, and with sufficient space about them to ensure a free circulation of air. Further, that thorough ventilation of houses is a necessity, that dampness of site and walls is a fertile source of disease, and that free access of direct sunlight plays an

important part in the promotion of health, largely owing to its direct disinfectant action. We know that the crowding of a large population within a limited area is a powerful predisposing cause of a high death-rate, and especially of a high infant-mortality. It is admitted that the walls and roofs of houses must be of such construction and thickness as to keep out the weather and extremes of heat and cold; that the interiors must be protected not only from damp, but from the escape of sewer-gas and from exhalations from the soil, and that the apparatus for the reception and removal of solid and liquid refuse must be of such construction and situation as to prevent contamination of the air, and to ensure the removal of the refuse from the premises as speedily as possible. Not only should there be an abundant supply of pure water to every house, but, where storage of water within the house is unavoidable, it should be so stored as to avoid the possibility of pollution.

Amongst the wealthy classes, these principles have only to be known to be applied. The law has stepped in to compel some attention to them on behalf of the poorer classes. Its earlier attempts were more or less abortive, but the Housing of the Working Classes Act (1890) has done and is doing much good, laying, as it does, upon the Sanitary Authority the duty of proceeding against owners of insanitary premises, and of causing sanitary inspections to be made, while in Urban Districts it empowers the authority to deal with unhealthy areas. Under the Public Health Act powers are given to Urban Sanitary Authorities to make by-laws with regard to new streets and buildings, model by-laws being issued for their guidance by the Local Government Board: cellar dwellings also are placed under very strict regulations. Apart from legal obligation, public and private philanthropy has done much, both in this country and abroad, to improve the condition of the dwellings of the poor.

5. *Notification of Infectious Diseases.*—Among sanitary improvements having less direct bearing upon the subject of this book, two stand out prominently—the notification of infectious diseases, and the prevention of food-adulteration. The notification of infectious diseases is compulsory in London, and under local Acts in many towns: it may be adopted by any Sanitary Authority. The advantages of the practice are very obvious, since it permits of exact and immediate knowledge as to the local prevalence of any given infectious disease, and enables the requisite steps to be taken to control it.

6. *Wholesome Food.*—The Sale of Food and Drugs Act of 1875, amended in 1879, has done much to place good and wholesome food within the reach of the poor.

7. *Registration of Plumbers.*—The registration of plumbers is a matter which

has a very direct and important relation to sanitary house-construction. Very much depends upon the accurate and conscientious manner in which plumbing is carried out, and it is much to be desired that evidence of competency should be forthcoming on the part of those who undertake it. It is too often the case that plumbing is entrusted to men who have not the necessary skill and training to do the work as it should be done. To remedy this state of things the Plumbers' Company of London, largely on the initiative of the late Mr. George Shaw, has instituted a system of voluntary registration, which has been in practice for some years past. There is every hope that such registration will shortly become compulsory by law, and that the woes of the long-suffering householder may thereby be largely alleviated. At the same time it appears only reasonable that the man who designs and specifies the plumbing of a building, as well as the man who executes it, should give evidence of his competence.

Improvements still required.—1. *Purification of Rivers.*—Although so much has been already attained in the way of sanitary improvement, much remains to be done, and is, indeed, already being attempted. It may be admitted that the Rivers Pollution Prevention Act of 1876 has not fulfilled all the expectations of its promoters. A good deal has been done to force towns to dispose of their sewage in other ways than by discharging it into rivers, yet trade pollution, especially about manufacturing towns, goes on much as before. Nowhere has the evil been so great as in the North of England, and it is noteworthy that the County Councils of some of the great manufacturing counties are now making earnest and concerted efforts to abate the nuisance. Satisfactory methods of sewage-disposal are still a great want for many of our large towns. Where the conditions are such as to allow of proper sewage-farming, the problem presents no great difficulty, but this is by no means always the case. The chemical and mechanical methods which have then to be employed are not only expensive and difficult of application, but wasteful, since valuable manurial matter is lost—the precipitated sludge containing but a small proportion of the available nitrogen of the sewage.

2. *Ventilation of Factories and Workshops.*—The proper ventilation of factories and workshops is a matter dealt with by various Acts, but the Factory and Workshop Act of 1895 has for the first time fixed by law the minimum amount of air-space to be allowed for each person employed, namely, 250 cubic feet per head during ordinary working hours and 400 for overtime, three gas-burners being accounted equal to one person. There is room still for improvement in the carrying out of the law in these matters.

3. *Smoke-consumption.*—In large towns the smoke-nuisance is one urgently

crying for reform. The chimneys of private dwelling-houses are untouched by the Public Health Acts, though factory chimneys are compelled to consume their own smoke as far as possible. Until the private chimney is touched, it is clear that no real abatement of the nuisance is possible, and it can only be when an economical, efficient, and satisfactory smoke-consuming grate is devised that any legislation on the subject becomes practicable. Grates which more or less fulfil these conditions are indeed in existence, but they have not as yet become popular.

4. *Improvement of Houses.*—Back-to-back houses, commoner in the north than in the south of England, constitute a very serious sanitary defect which is not yet specifically dealt with by law. Even in some large towns,—*e.g.* Leeds,—they are still permitted to be built, though it has been conclusively shown, by Barry and Gordon Smith amongst others, that the lack of air-space and ventilation which they engender is associated with a distinct increase in the death-rate.

5. *Improved Inspection of Houses.*—The sanitary inspection of houses is susceptible of considerable development and improvement, especially in the matter of uniformity. Stringent by-laws may exist under one Sanitary Authority, while considerable laxity may prevail in an adjacent area. Moreover, it is too often the case, especially in small towns, that personal interests are allowed to interfere with the due application of such by-laws as may be locally in force. Better results would be obtained if house-inspectors were appointed either by County Councils or by Government.

Effect of sanitary improvements on death-rate.—If polluted water, vitiated air, bad drains, damp sites, overcrowding and dirt, be really important factors in the causation of disease, then it should be demonstrable that the improvements in these matters, which have been going on for the last half-century, have resulted in a material diminution of disease and death. Such evidence is abundantly forthcoming, in this and other countries, in the diminution which has been brought about in the death-rate. In the absence of statistics of population, no positive statements can be made as to death-rates in England before the rise of modern sanitation, but it seems fairly clear that in the eighteenth century the death-rate was at least double what it is now. It is not till the middle of the present century that detailed mortality-statistics are available. In 1858 the death-rate for England was 23·1 per thousand per annum; it has now for ten years past averaged rather less than 20, and indeed, in 1894, it reached the unprecedentedly low figure of 16·6 per thousand, though in 1895 it again rose to between 18 and 19. The reduction has been a gradual one, and much of it is due to a reduction in child-mortality. Ogle calculates that, contrasting the periods of 1841–70 and 1881–85, the mean annual mortality has fallen by 12·44 per cent for males, and 14·95 per cent for females. Figures from abroad are equally instructive. Between 1871 and 1892 the city of Berlin spent no less than nine and a half millions sterling on sanitary works. In 1876 its death-rate was 29·32 per thousand, and this has steadily diminished to 20·89 in 1892. That for the whole German Empire shows a very similar drop, from 29 per thousand in 1872 to 22·3 in 1894. During the above-mentioned period in Berlin the infant-mortality has fallen by nearly one-half. In Paris also, in which city great sanitary progress has been made, the death-rate has fallen from 25·37 in 1880 to 21·8 in 1893.

It must of course be remembered that the effect which sanitation can produce upon the death-rate is a limited one: we must all die sooner or later. Its effects are shown less in a decrease in the general death-rate than by its influence on so-called preventible diseases—notably on **zymotics** and **tuberculosis.** Some zymotics appear to be little influenced by sanitary improvements: measles and whooping-cough show no diminution, diphtheria has even increased. The decrease in small-pox mortality is due mainly to vaccination, and cannot fairly be adduced in evidence. But typhus fever, which in 1869 killed 193 per million living, has gradually abated till, in 1891, it killed only 5 per million. It has been practically abolished from the south of England, and the same is true of relapsing fever. Scarlet fever, at the commencement of Queen Victoria's reign, was killing her subjects at the rate of 797 per million per annum; in the quinquennium 1886–90 this number had fallen to 241, and in 1894 it was only 167. Typhoid fever, the mortality from which is, perhaps, the surest index of sanitary condition, has declined from a death-rate of 390 per million in 1869 to 168 in 1891, and 159 in 1894. The terrible mortality which cholera formerly caused when introduced into this country has become a thing of the past; within the last few years it has been many times introduced, and has failed to obtain any foothold at all. The mortality from phthisis shows a reduction almost as striking as that from zymotic disease. In 1838 no less than 3996 persons per million of the population died from this cause. The number has very gradually and steadily decreased to 1599 per million in 1891. How important a share sanitation can play in the reduction of phthisis-mortality is shown by Buchanan's well-known figures dealing with the effects of drainage in certain towns; in Ely the phthisis death-rate was reduced by 47 per cent, and in Salisbury by 49 per cent, by this means alone.

The death-rates in town and country are not alike: the aggregation of people in large towns has always produced a prejudicial effect on health.

From 1882–86 the urban death-rate per thousand was 20·3, the rural 17·7. In 1894 the figures were respectively 17·1 and 15·6. Urban and rural death-rates are gradually approximating as towns become more healthy. It would be easy to multiply figures, but enough has been said to prove the enormous part which sanitation has played in reducing the mortality from preventible disease.

CHAPTER II.

THE PRODUCTION OF DISEASE BY INSANITARY CONDITIONS.

In order that the reader should grasp the reasons for the various principles which are to be inculcated in this work, it is essential that the effects of insanitary conditions in producing disease should be discussed in some detail.

Diseases conveyed by Impure Water.—It is hardly necessary to discuss the effects of an inadequate supply of water for domestic purposes. Such a condition leads to personal uncleanliness, to dirty houses, and to imperfect flushing of drains,—in other words, to a state of affairs in which not only are the specific germs of disease harboured and propagated, but the powers of resistance against them considerably lowered. The main point to which attention is here called is that certain specific diseases are spread by the contamination of drinking-water with their germs. Chief among them are the infectious maladies characterized by diarrhœa—to wit, **cholera, typhoid fever, dysentery,** and **summer diarrhœa.** We now believe that these diseases are due to specific micro-organisms, and in the case of the two first-named our knowledge of the disease-germs is detailed and accurate. We know that they pass from the bodies of those affected by typhoid or cholera with the excreta, and that they are capable of living for some time outside the body. They are thus disseminated in the sewage, and where defects exist in drains or cesspools they may escape into the soil and contaminate surface-wells. Streams from which water-supplies are drawn may be infected, or even the main water-supply of a town. Numerous instances are on record in which disastrous outbreaks of cholera and typhoid have been traced to the contamination of public water-supplies by sewage containing the excreta of persons suffering from these diseases. In the cases of dysentery and simple diarrhœa the evidence is strong in the same direction, *i.e.* that certain outbreaks have resulted from the consumption of polluted drinking-water, but it is not generally thought that this is the principal way in which these diseases spread. There is reason to believe that in malarious districts, drinking-water forms one way in which the specific parasite of malaria gains access to the system.

The pollution of water by organic and even fæcal matter, apart from the germs of specific disease, is a different question. Until recent years such contamination, as shown by chemical analysis, was the only available evidence against a suspected water-supply. It still remains evidence of value, since it indicates possible contamination by specific disease-germs, but bacteriological examination now constitutes an indispensable adjunct to chemical analysis. It is possible that dissolved or suspended organic matter in drinking-water may be a direct cause of diarrhœal or other disease, though it is difficult to exclude the effect of the microbes which must be present under these conditions. The main water-borne disease to be dreaded in this country is typhoid fever; cholera would in case of its introduction be equally to be feared. The other zymotic diseases are rarely, if ever, conveyed by water.

It must further be observed that certain mineral impurities in water are capable of causing disease. Excessive hardness of water may give rise to **dyspepsia**; the prevalence of **calculus** in certain districts has been ascribed, though on little evidence, to peculiarities in the water; **goitre** very probably depends on some as yet unidentified mineral ingredient in water, though this seems certainly not to be carbonate of lime. The chief mineral impurity to be guarded against in a domestic water-supply is lead, which, when continuously absorbed—even in minute quantities—induces **lead-poisoning** with its various troubles—amongst others anæmia, constipation, severe colic, and local paralyses. The source of the mischief in these cases is, of course, the lead used in plumbing-work, and it is to be noted that the degree to which different waters attack lead varies largely, the purer and softer waters, especially those containing free acid, doing so far more than the harder waters. It is believed also, as the result of experiment, that bacteria may play a part in the action of water on lead.

Lastly, the introduction of certain intestinal and other **parasites**, in the form of egg or embryo, is a possibility not to be lost sight of in considering water as a source of disease. This can only occur as the result of gross impurity, and the danger is probably far less in this country than abroad.

It results from the above considerations that much attention may justly be devoted to the purity of the drinking-water in a house. Purity of source is the first essential. Where the supply is derived from rivers or lakes, it ought to be filtered by the water company before distribution; but it must be remembered that filter-beds do not remove all or nearly all the micro-organisms from water, and may at times, especially during severe frosts, be very imperfect in their action. This is the case too during the first day or two on which a filter-bed is used. It is therefore a wise precaution to employ either boiling, or efficient domestic filtration, in all cases.

Domestic filtration will be dealt with in detail in a subsequent chapter, but the principles which should underlie it may be noticed here. The aim of filtration is to deprive water of foreign matters, and especially of those micro-organisms which have been shown to produce disease. The bacteriological study of the subject has shown that this aim is not only unfulfilled in most of the old-fashioned filters in which we have been accustomed to repose such simple trust, but that, when they have been for any time in use, the filtering medium becomes so thickly impregnated with bacteria, all alive and growing, that it may positively add them to the water. Few filtering media are so fine as to exclude bacteria, and when they do so the process of filtration is so slow that considerable pressure has to be employed. Such pressure is fortunately available in most houses in the service-pipe itself, or from the hydrostatic pressure of the column of water from the top of the house. High-pressure filters are the best and safest for domestic use, but they nevertheless require frequent attention and cleaning if they are to deliver a supply of really sterilized water.

Where the domestic water-supply is intermittent, the **storage of water** in cisterns is necessary, and this is not undesirable even under a constant supply, since the latter may possibly fail in time of drought or when mains are frozen or burst. Unless proper precautions are taken, cisterns may be a source of danger. The ordinary form of cistern, imperfectly covered by a wooden lid, is not an arrangement to be recommended; the water is liable to various sources of contamination from air and dust, sometimes even from sewer-gas where the constructional arrangements are bad; drowned rats and sparrows are not unknown; periodical cleansing is frequently neglected, or performed at too-long intervals. The ideal cistern, as pointed out by the recent Commission on the East London water-supply, is a mere expansion of the service-pipe, perfectly closed except for a minute air-valve, and preferably of a conical shape, so as to be self-cleansing.

Diseases due to Impure Air.—Numerous diseases arise from the breathing of impure air. Air may be vitiated by respiration or by the products of combustion; it may contain irritating mechanical particles or noxious gases and vapours; it may act as the carrier of specific germs, and this especially in the absence of free ventilation and sunlight, which are potent factors in the removal and destruction of such germs. Respiration vitiates air by depriving it of oxygen, and charging it with carbonic acid, water-vapour, and certain little-understood putrescible organic matters arising as exhalations from the animal body and given off mainly from the lungs and skin. The last-named impurities are admittedly the main injurious agent in air fouled by respiration, and are the cause of the close, unpleasant smell in ill-ventilated or overcrowded living-rooms; the amount of carbonic acid present is some sort of index of the proportion of this organic matter in the air. The combustion of fuel, coal-gas, and other illuminants, vitiates air by abstracting oxygen, adding carbonic acid and water-vapour, and—especially where combustion is imperfect—other and more poisonous gases, such as carbon monoxide. One of the main advantages of electricity as a domestic illuminant is the absence of this vitiation of the atmosphere. The effect of breathing air polluted in these ways may be **acute asphyxia** where the pollution is excessive, as in the historical instance of the Black Hole of Calcutta. The common result of persistent lack of proper ventilation is an undefined condition of general ill-health characterized by **headache, languor,** and **anæmia,** in which the system has a much-lowered resistance against the specific agents of disease—tubercular disease in particular.

The effect of the irritating dusts produced in certain trades, such as steel-grinding, tin-mining, and various textile industries, shows itself in a largely-increased mortality from **lung-diseases.** Improved air-space and ventilation, with the introduction of appliances for the mitigation of the dust, have done much to diminish this heavy mortality.

Chemical-works and other manufactories often give rise to offensive effluvia, but the objection to these is usually an æsthetic one; it is nevertheless sometimes the case that health is impaired in this way, though it is doubtful whether any specific disease can be produced. Where typhoid fever has occurred in connection with sewage-farms, it has probably not been air-borne.

From a domestic point of view, one of the chief air-pollutions to be guarded against, is that due to the escape of coal-gas. In extreme cases the result may be fatal,—probably from poisoning with carbon monoxide,—and even small leakages of coal-gas, if continued for some time, may lead to **headache,** and **general deterioration of health,** and in some cases to **sore throats.**

The different infectious diseases vary in the degree to which they are liable to be conveyed by air. In some the poison is readily oxidized and destroyed. It is an old saying that, if the window be opened, typhus goes out. **Typhus fever** is a disease the poison of which is easily destroyed by fresh air. **Small-pox,** on the other hand, may be carried through air for considerable distances, and experience has shown that the aggregation of small-pox patients in special hospitals in towns is on this account a source of measurable danger to those living in the vicinity. The germs of other zymotic diseases, such as **scarlet fever, diphtheria, measles,** and **influenza,** may also be carried by air. In the ease with which fresh air can destroy the poison, these are intermediate between typhus and small-pox. The danger of conveyance of these diseases by air is probably slight, except in the immediate neighbourhood of the sick person.

Consumption is a disease with which impure air has very definite relations. As already mentioned, under conditions of overcrowding and bad ventilation a state of ill-health is established in which liability to the disease is much increased. But this is not all. The tubercle bacillus, which is the direct infecting agent, is coughed up in enormous numbers in the expectoration of consumptive patients. Nuttall calculated that in a moderately-advanced case from one-and-a-half to four billions of bacilli were expectorated daily. Where, as is commonly the case, no pains are taken to collect and destroy the expectoration, it is liable to be scattered about, dried, and disseminated as dust; and it is known that the bacilli retain their vitality in the dried condition for many months. It follows that the dust of dirty and ill-ventilated houses in which consumptive patients have lived may produce the disease when inhaled by a susceptible person, and such houses may become positive centres of infection. It should be added that direct sunlight and fresh air are important agents in the disinfection of such premises. Direct sunlight was found by Koch to kill tubercle bacilli within a few hours, and bright diffused daylight in a few days. Similar facts are known with regard to other resistant microbes, and they enforce a very salutary lesson in sanitary house-construction.

The *air of sewers* has always had the reputation of producing disease to a marked extent, and, indeed, the evidence that sewer-gas escaping into dwelling-houses has various injurious effects is so strong as to admit of little dispute. Its precise mode of action is, however, somewhat obscure. The composition of sewer-air varies widely with the perfection of the ventilation and the nature of the sewage. In well-ventilated main sewers the air shows on analysis a moderate excess of carbonic acid, with traces of marsh-gas and sulphuretted hydrogen, and a little ammonia. It is air which can be breathed without injury for considerable periods, and it is well known that the men employed in sewers do not suffer much, if at all, in health as a consequence of their avocation. The air of unventilated sewers, however, may become irrespirable and even explosive, and cases of acute sewer-gas poisoning, characterized by **vomiting, purging, headache,** and **prostration,** sometimes occur, and occasionally end fatally. The air in house-drains also, which is that immediately escaping into houses, is often dangerous, as the ventilation of small drains is always difficult, and too frequently the means adopted are utterly inadequate.

What is the deleterious factor in sewer-air to which these symptoms, and the more insidious effects produced by its escape into houses, are to be attributed? The discovery that many diseases are caused by bacteria made it natural to assign the ill effects of sewer-air to its action in conveying the specific germs of disease. But, in spite of the plausibility of this suggestion, actual experiment is in opposition to it. Miquel, Carnelly and Haldane, and, more recently, Laws, have shown that the number of bacteria in sewer-air is actually less than in fresh air at the same time, and very considerably less than in the air of houses. Moreover, it was shown by Laws that the micro-organisms present in the air of London sewers were related to, and presumably derived from, those of the fresh air, and bore no sort of relation to those which are present in the sewage. There exists no proof that, under ordinary circumstances, sewage gives up bacteria to the air in contact with it; and there is reason to believe that it does not do so under any circumstances, except where an extreme amount of splashing is produced. Where sewers are blocked and ventilation inadequate, there the number of bacteria in the sewer-air has been found to be exceptionally low. It would hence appear that some other cause must be found for the deleterious effects of sewer-air. It can hardly be supposed that, when largely diluted after escaping into a house, it can owe its evil properties to its gross chemical composition. Something more subtle than this must be at work, and it has been suggested that the organic matter present in it may contain an obscure chemical poison, possibly of an alkaloidal nature. There is, however, no proof of this.

Although no definite explanation can be offered as to the way in which sewer-air produces disease, the observed facts show beyond reasonable doubt that its escape into houses constitutes a serious source of danger to those dwelling therein. The diseases which in particular have been ascribed to this condition are **diarrhœa, typhoid fever, diphtheria** and other forms of **sore throat, pneumonia, erysipelas, puerperal fever,** &c. Most, if not all, of these are specific diseases due to definite and well-known microbes, and, as has just been stated, there is no evidence of the carriage of such microbes by sewer-air. It cannot, however, be doubted that the constant inhalation of even diluted sewer-air,—which in concentrated form has been known to cause acute mephitic poisoning,—must so lower the resisting powers as seriously to predispose to these specific diseases, and to render them much more severe when they occur. It must also be borne in mind that where the sewers are faulty, and sewer-air can escape into houses, there the subsoil and ground-air are liable to pollution, with possible contamination of the water-supply. Where one sanitary defect exists others are often present at the same time, so that the causation of disease may in such cases be complex.

Where water is stored in a house, special care must be taken to avoid contamination of the cistern by sewage-emanations. For this reason it is essential that cisterns serving water-closets should be separate from that from which drinking-water is taken, and that waste-pipes from cisterns should have no connection whatever with soil-pipes or other possible sources of effluvia. Food is commonly stored in the basements of houses, where the liability to contamination by exhalations from drains and ground-air is greater than elsewhere. Organic matters such as food readily absorb emanations of this sort, and have been shown to undergo putrefactive changes much more rapidly when exposed to contamination by sewer-air. This may constitute a very real source of danger. Milk in particular should never be stored where there is the slightest possibility of its contamination. It forms so excellent a breeding-ground for bacteria that their access to it is peculiarly harmful, and this especially as it is so largely used for the food of young children. The methods devised to obviate such risks will be discussed in full detail in ensuing chapters.

Diseases due to Cold and Damp in Houses.—These conditions may be considered together, for as factors in the causation of disease they usually go hand in hand. A damp house is commonly a cold one, and a cold house is liable to be a damp one, because the condensation point of water is directly dependent on temperature.

The maladies produced by cold and damp are different from those which we have previously considered. Amongst the most important are diseases of the respiratory organs. The too familiar "**common cold**" is a complaint the causation of which is not yet thoroughly understood. In many, perhaps in all, cases it is a truly infectious disease, as is shown by its capacity for running through a household; but the specific microbe is not at present certainly recognized. Nevertheless chill, and especially sudden changes of temperature, are universally admitted to play an important part in its production, and this very rightly, the effect of these being to depress vitality and diminish the powers of resistance against infection. The same is true of **pneumonia.** It is known that this disease depends upon a specific microbe—the *Diplococcus pneumoniæ*,—but the effects of chill upon its production are undoubted, and are to be explained in the above manner. **Pleurisy** and **bronchitis** are other respiratory diseases which have a definite relation to cold and damp.

Two diseases, however, stand out pre-eminently as favoured by the above conditions: they are phthisis and rheumatic fever. In the production of **phthisis** cold alone seems to play an unimportant part, save in so far as the production of catarrhs increases the liability to infection by the tubercle bacillus. An equably cold but *dry* climate does not appear to conduce in any way to phthisis, except by leading to deficient ventilation. Damp, however, has been shown by Buchanan in this country and by Bowditch in America to play a very important part in predisposing to the disease, dampness of soil leading to a high phthisis-mortality, which in many cases has been materially reduced by artificial drainage. A contemplation of the map of phthisis-mortality in this country, prepared by Havilland, illustrates strikingly the effects of climate in this direction. The combination of cold and damp is probably more injurious than damp alone; but it must be remembered that they are only two of the conditions which lead to the disease, which itself invariably depends upon infection by the tubercle bacillus. We do not know whether **rheumatic fever** is a bacterial disease or not, but there is no question as to the close relation which exists between its prevalence and conditions of cold and damp. Sleeping in a damp bed is a not uncommon cause of the complaint, and cold and damp in the house are probably as directly connected with it as coldness and dampness of climate. The chronic forms of rheumatism and allied diseases are notoriously aggravated by these conditions. **Neuralgias** often are to be traced to similar causes. **Malaria** has almost disappeared from Britain, but in other countries the blood-parasite which is known to be its cause is most commonly present in damp and low-lying localities.

Diseases due to Dirt and Overcrowding.—Overcrowding must be regarded from two points of view. The individual requires a certain amount of air-space for the due preservation of his health. Therefore, too many people must not be crowded into a single room. The population of a town district requires a sufficient amount of fresh air and sunlight. Therefore, too many rooms must not be crowded into a limited area by increasing the height of the buildings, even though each room contain only its due number of inhabitants. The violation of these rules leads respectively to what are known as lateral and vertical overcrowding. As regards the former, the Model By-laws suggest 300 cubic feet per head as the minimum air-space for dwelling-rooms. Various building acts and by-laws regulate the height of buildings in relation to width of streets, and also the amount of air-space to be left at the backs of houses. The evils of overcrowding are mainly those of deficient ventilation already alluded to. Statistics show very clearly the relation between a high death-rate and density of population. But it must be borne in mind that in these cases it is not merely overcrowding which is to blame: other insanitary evils are commonly also present, and it is the poorest class, badly-clad and ill-fed, which commonly inhabits an overcrowded area.

Dirt has a good deal to do with the production of disease, and this in several ways. Uncleanliness of person prejudices the health of the individual by impeding the free action of the skin, and not only his own health but that of those around him, by increasing the amount of organic effluvium in the air. A dirty person is more likely than a cleanly one to carry about with him the germs of infectious disease. The value which is attached nowadays to personal cleanliness is shown by the increased demand for bathrooms in houses, and there can be no doubt that a daily bath largely increases the robustness of the individual and his capacity for resisting disease. Uncleanliness of the dwelling produces much the same effects as personal uncleanness, and is usually associated with it. Dust and dirt are media which harbour the germs of disease: soap and water, fresh air and sunlight, are the cheapest and most effective disinfecting agents. In the construction of hospitals it is now common to round off all angles at the junction of wall and floor, and to lay down parquet floorings which leave no wide cracks in which dirt can accumulate. In this way a serious source of danger is avoided. Dirt in houses consists largely of organic matter, some of which is liable to decomposition, whereby the impurity of the air is increased. The condition of an ash-pit which has remained long unemptied may be repeated in miniature in the unswept corner of a room. Of the grosser forms of uncleanliness in dwelling-houses there is scarcely need to speak here; the points upon which stress should be laid are the removal of all dust and dirt, and the avoidance of everything which can harbour them.

CHAPTER III.

DISINFECTION.

In spite of the care which may have been spent on the sanitary condition of a house, infectious disease may at times be imported into it from outside. Certain considerations then arise which are not outside the scope of this book. Where the case is treated at home, isolation is, of course, imperative, and the choice of a suitable room is of great consequence. It should preferably be at the top of the house for the sake of light and airiness, and because the chances of infecting others are thus lessened: the air-currents in a house pass upwards. It should be reasonably large, well-ventilated, and, if possible, with a light and sunny aspect. It should have a fireplace, for a fire is desirable in any but the most sultry weather, not only to assist ventilation, but for the ready cremation of rags or other material which have received infectious discharges from the throat or nose of the sick person. All curtains, carpets, and hangings must, of course, be removed, and only such articles as are absolutely needful should be left in the room, and these should be such as are susceptible of ready disinfection afterwards. It is customary to hang outside the door a sheet soaked in some disinfectant, and the practice is at all events of use as a danger-signal. It is useful to place outside the door a bath containing an active disinfectant (such as five per cent carbolic acid), so that cups, spoons, and other articles used by the patient may be placed in it before being taken downstairs to be cleaned.

The relative value of **disinfectants** is so largely misunderstood by the public, and a proper knowledge of them is so important in house-sanitation, that a few words on the subject should not be amiss here. A disinfectant, as its name implies, is an agent which, applied in a certain strength and for a certain time, is capable of killing the germs of infectious disease. **Carbolic acid** is a disinfectant when properly employed, but to sprinkle a little pink carbolic powder down a gully-hole or privy is a useless proceeding except for deodorizing purposes, and may be actually mischievous by creating a false feeling of security. The facts that require to be insisted on are as follows:—Bacteria which do not form spores are killed by five per cent carbolic acid (phenol) in five minutes, but the highly-resistant spores formed by some species of bacteria require at least twenty-four hours' exposure to this solution before they perish. It is probable that most of the germs of our ordinary fevers do not form spores, but it is not safe to assume this; indeed, in the case of small-pox, the most recent evidence points to a spore-bearing bacillus as the cause of the disease. Carbolic acid, to be an efficient disinfectant, requires to be present in the proportion of one part in twenty of the total volume of the material to be disinfected, and contact should last at least five minutes, and in the case of spore-bearing bacteria, twenty-four hours. The cheaper dark commercial brands of "carbolic acid" are mixtures of phenol, cresol, and tar oils, but cresol seems equal to phenol in disinfectant action.

The most powerful chemical disinfectant we possess is **perchloride of mercury** (corrosive sublimate). A solution of this salt, of the strength of 1 in 500, kills the most resistant spores in about a minute, while one of 1 in 5000 kills bacteria which form no spores, equally quickly. It is by far the surest disinfectant, but it has the disadvantage of being a very deadly poison. It has, further, for household use, the disadvantage that it must not come into contact with metals, since it damages them, and is itself, at the same time, rendered ineffective.

The majority of the so-called "disinfectants" sold under fancy names are unreliable, though many of them have a valuable deodorant or antiseptic action. Where a genuine disinfectant action is required in a short time perchloride of mercury is the safest substance to rely on; or, failing that, carbolic acid of at least 5 per cent strength.

The practice of disinfection by **fumigation** is much in vogue, but not much reliance should be placed on it. The old-fashioned method of burning sulphur is not thoroughly efficient, even when well carried out. Chlorine is a better aërial disinfectant, but its application is troublesome. Even in a well-sealed room it is very difficult to keep up the percentage of the gas requisite for genuine disinfection for the necessary length of time: nevertheless, such methods are better than nothing. The method, used in Paris, of spraying an infected room and its contents with a solution of perchloride of mercury of the strength of 1 in 1000 by means of a powerful force-pump termed a "pulverisateur" is a much more effective and rational procedure.

Heat is the most speedy and convenient disinfectant we possess. Only the more resistant spores of bacteria are capable of withstanding the temperature of boiling water, and this only for a short time. Moist heat is better than dry, and steam under pressure is the best of all means for disinfecting clothing and bedding on account of its rapid penetrating power. Many sanitary authorities now possess the apparatus necessary for this purpose.

The foregoing facts may now be applied to the **practical disinfection** of a house where infectious disease has occurred. In the case of diseases such as diphtheria or scarlet fever, where the secretions from the nose and throat are infectious, such secretions should be received on old rags and at once burnt. In typhoid fever and cholera, where the discharges from the bowel are the main infecting agents, they should be treated with a large excess of at least 5 per cent carbolic acid or of a solution of perchloride of mercury (1 in 1000), and they should remain in contact with the solution for an hour or two, the solid portions being well broken up. They may then be poured down the water-closet in towns, but in the country they should preferably be deeply buried, remote from any water-supply. At the close of the illness the room and furniture should be superficially disinfected by spraying with perchloride of mercury solution (1 in 1000), or by thorough fumigation with chlorine or sulphur for twenty-four hours. If the latter has been properly done, and the room previously rendered air-tight by pasting up all cracks and crevices, the air should be nearly irrespirable when the room is opened after twenty-four hours. All bedding and hangings should then be removed and disinfected by steam under pressure. The floor, walls, bedstead, and other furniture must be well scrubbed with 5 per cent carbolic acid, or, better (except for articles made of metal), with perchloride of mercury solution (1 in 1000), the paper removed from the walls, and re-papering and whitewashing performed. During these latter processes as much fresh air and sunlight as possible should be admitted into the room, which is then ready again for habitation.

CHAPTER IV.

THE DISPOSAL OF REFUSE.

House-refuse consists of ashes, and the remains of food, both animal and vegetable, of the waste water from sinks and baths, and of human and animal excreta, liquid and solid.

Refuse food should be for the most part burnt, so that the solid house-refuse ought to consist mainly of ashes. The old-fashioned brick **dust-bin** has now been very advantageously replaced by a movable galvanized iron receptacle with a well-fitting lid, which has the useful qualities of being easily emptied and cleansed, and of being non-absorbent: its superiority to the brick dust-bin, from a sanitary point of view, admits of no dispute. It should be emptied often—not less than twice a week in summer and once in winter.

The waste water from a house is charged with putrescible organic matter, and is rich in soapy and fatty substances and dirt of various kinds. In a town not provided with water-closets it is this which, diluted with rain water and subsoil-water, forms the bulk of the **sewage,** though liquids from stables, urinals, &c., may also enter the sewers. The large amount of organic matter in such a liquid will be realized when it is stated that the Rivers Pollution Commissioners found little or no difference in the composition of sewage, whether water-closets were in use in a town or not—*i.e.* whether it contained the solid excreta of the population or not. The average amount of excreta per head of the population is assumed by Parkes to be 2½ oz. of fæces and 40 oz. of urine. The total volume of sewage per head of the population varies in towns according as the rainfall and subsoil-water are admitted to the sewers or not: in most English towns it is from 30 to 40 gallons *per diem.*

In sewered towns the most speedy and economical method of getting rid of excreta from houses is undoubtedly **water-carriage,** gravity (which costs nothing) acting as the motive power. Some form of drainage is needful to get rid of the waste water of a household, and experience has shown that the danger of sewer-air entering the house is not materially increased by water-closets where these are of good construction, and where the whole drainage-system is properly trapped and disconnected. In isolated country-houses the method may also be applicable provided that suitable means exist for disposing of the liquid sewage —*i.e.* where it can be utilized for the irrigation of fields without prejudice to health, or even employed for garden purposes, or where it can escape into the ground without danger of the contamination of wells or streams. In the houses of the poorest classes in towns water-closets are so liable to misuse and blocking that they are undesirable unless a rigid system of sanitary inspection can be practised.

In such cases and where no sewerage system is present,—as is usually the case in the country,—water-carriage is unsatisfactory, since **cesspools,** unless most carefully constructed, are a source of serious danger in the neighbourhood of houses. The **midden** or **privy** of our forefathers is in any case liable to be a nuisance, and one which becomes intolerable at the time when it is emptied. The system of **pail-closets,** in which the excreta are deodorized by the addition of ashes or earth, has, on the contrary, much to recommend it: it is simple and cleanly, and the small size of the receptacle necessitates its frequent emptying. In towns the household ashes, duly sifted, afford an excellent means of deodorizing the excreta; in the country, where a sufficient supply of earth is available, earth-closets can be used with great advantage: the deodorizing and disintegrating effects of dry earth upon fæcal matter are very pronounced. Whatever material is used for deodorizing, enough of it must be added to ensure complete dryness of the product.

The ultimate **disposal of sewage** is a problem that can only be briefly referred to here. Where dry methods of removal are in use, the products can be directly added to the land as manure. Water-carriage involves such great dilution as to render their application to land much more costly and troublesome. Sewage-farms have proved a successful solution of the difficulty where suitable sites can be obtained, perhaps nowhere so strikingly as at Berlin, where an arid, sandy soil has been rendered capable of bearing abundant and remunerative crops. The conditions which can make sewage-farming pay are not everywhere attainable: in many places, indeed, the purification of sewage by land-treatment is impossible. Then arises the difficulty of getting rid of large volumes of sewage without injury to health. On the coast it may be discharged into the sea, if its washing back on to the foreshore can be avoided. Its discharge, untreated, into streams is only permissible where the volume of water in the stream is vastly in excess of that of the sewage, and a sufficient distance intervenes between the point of discharge and the nearest town or water-intake, as to allow of the complete oxidation of organic matter and the destruction of bacteria dangerous to health. Neither condition is easily attainable in a thickly-populated country like England, and the absolute prohibition of river-pollution by sewage ought to be enforced. Various processes have been devised for purifying sewage and rendering the effluent so harmless that it may be discharged into streams without danger, and mention will be made hereafter of such processes as come within the scope of this work.

The householder or architect may, however, be called upon to decide what method of sewage-disposal is to be adopted in an isolated country-house, and the principles which should guide him have been already discussed. If suitable facilities exist, and no danger of the contamination of water-supplies arises, water-carriage may be employed. If there is a large garden, a well-constructed cesspool is permissible, if it be duly ventilated and at least 50 feet from the house and 60 to 80 feet distant from any well, spring, or stream. Greater distances are more desirable. The sewage can be pumped up and utilized in the garden to the great advantage of the fruit and vegetables grown therein. The overflow must be conducted where no possible danger can arise from it. Larger areas of land may be treated by broad irrigation—the method which appears to get the greatest manurial value from the sewage, but where nuisance arises, sub-irrigation—a method which has been largely adopted in America—is preferable. If no sufficient area of land exists for the disposal of liquid sewage, dry methods of carriage must be employed, and of these, earth-closets are the most convenient in the country, though ashes or charcoal may be used if preferred. Under these circumstances the waste water from the house may be conducted to a suitable permeable chamber in the soil and allowed to soak away where it cannot contaminate any water-supply.

CHAPTER V.

GENERAL PRINCIPLES.

An attempt has been made in this introductory section to enunciate the principles which underlie the construction of healthy houses, to set forth the reasons which lead up to them, and the results which may arise from their non-observance. It will be fitting to conclude with a brief summary of these principles as they apply to the sanitarian and to the householder himself. To both some knowledge of the factors causing disease and of the ways in which diseases spread is absolutely essential.

The sanitarian is concerned with the choice of a suitable site for the house, cold and damp being the two things to be avoided if possible. The proper drainage of the site, the exclusion of ground-air and other exhalations from the soil, and the weather-proof construction of the house itself, are all points to which he must pay attention. A due amount of air-space about the house, so that an abundance of fresh air and sunlight may gain access to it, is a condition essential to its healthiness. The internal ventilation and warming of the house are matters which must call for his utmost care, as must also the provision of an abundant supply of pure water. In this connection he must consider not only purity of source and freedom from danger of contamination by sewage, but likewise the safe and adequate storage of water within the house where such is needful. No matter must engage his more careful consideration than the system of drainage to be adopted in relation to the method of sewage-disposal which is at hand. He will be primarily responsible for the proper construction of the drains, and must insist upon good workmanship, adequate disconnection from the sewers, and proper ventilation of soil-pipes and drains, whereby the dangers of escape of sewer-gas into the house are avoided. These are the main essentials upon which the healthiness of a house depend.

But when all is done, and **the householder** enters into possession of his ideal premises, replete with every device which modern sanitation can suggest, he must reflect that upon him devolves the duty of keeping the house healthy. In vain will the contriver of the house have planned his efficient ventilation unless due attention be paid to it afterwards. Windows are designed to admit sunlight: pulling down the blinds may save curtains and carpets for a time from fading, but fading health is a worse evil than fading carpets. Windows are made to open, and stuffiness of rooms, and especially bedrooms, is far more likely to lead in the long run to colds and coughs than where fresh air can play freely about a room. It is scarcely too much to say that it is healthier to sleep in a draught than in a stuffy bed-room. The overcrowding of rooms, and especially of bed-rooms, is an evil carefully to be guarded against.

No house, however carefully planned, can be healthy which is allowed to become dirty. Soap and water are the main weapons with which, in conjunction with fresh air and sunlight, the householder can war against disease. His water-supply also will require vigilant attention. Most cisterns require periodical cleansing, and this should be done *at least* twice a year. He should understand the principles of domestic filtration, and not be content with any appliance merely because it is sold as an efficient filter. Filters can be easily tested by any bacteriologist at a small cost. However good the drains may have been when laid down, defects are liable to occur in the course of time; they therefore require periodical inspection and even testing. Moreover, accumulations of filth may occur in them: regular flushing and removal of the contents of gully holes, grease-traps, &c., should be looked to. Care also must be taken that the scavenger pays his visits with regularity and efficiency. When plumbing or other work requires to be done, the householder must remember that good workmanship is the essential requirement, and that cheap, superficial work is the least economical in the long run. Lastly, he should know what precautions should be taken in the way of isolation when infectious disease arises in his house: he should put no blind trust in any curiously-named substance sold as a disinfectant, but should know what to use and how to use it, and have reasons for the faith which is in him.

The aim of house-sanitation is to lower the death-rate and to promote the health and well-being of house-occupants. Every one has a direct interest in lowering his own death-rate and that of those dependent on him, and in living his life under conditions most conducive to health, happiness, and capacity for work. How this may be done, so far as concerns immediate external surroundings, it is the object of this book to set forth.

SECTION I.—PLAN

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SECTION I.—PLAN.

CHAPTER I.

GENERAL CONSIDERATIONS.

Comfort.—In no other country have the amenities of home-life been so well developed in respect of the plan of the dwelling as in the British Islands. This is partly due to the climate, and partly to the domestic habits of the prosperous classes. In other words, people are obliged to live indoors, and many can afford to make themselves very comfortable there. It is of course in the country, and in the residences of the more wealthy, that the organization of the interior of the house becomes thoroughly elaborated; but none the less in our middle-class dwellings innumerable examples may be found in which domestic convenience is almost unconsciously perfected, and the conditions of family enjoyment exquisitely fulfilled.

To make a thoroughly comfortable house, every apartment must be planned by itself, and for its own uses; and the designer will do well in all cases to take into account—in fact, to plot upon his paper plan—the disposition of the furniture. There are too many dining-rooms, for example, in which the place for the sideboard is by no means easily determined, and too many bedrooms in which there is no proper place for the bedstead; which is surely inexcusable.

Health.—That a family dwelling should be healthy, or primarily devoid of all elements of insalubrity, may go without saying; but, even in a matter apparently so simple, it does not follow that careful design can be dispensed with; indeed, the scientific question is not generally recognized as it ought to be. We are apt altogether to overlook the fact that we live in an ocean—that of the air,—the purity of whose chemical composition is life and joy to us, and its impurity disease and misery. Upon the bed of this ocean, also, we form patches of incrustation, large or small, which we call our towns, composed of multitudinous individual nests called our houses—elsewhere also scattered about singly,—in which we take up our abode and follow many of our occupations, confining the air by unnatural restraints, compromising its purity in a hundred ways of negative neglect and positive disorganization and defilement, and, indeed, too frequently so doing with a thoughtlessness almost childish in its innocent complacency. What with our own breathing or blood-cleansing, our skin-waste, our fires and smoke, the dust from our upholstery and clothing, our drainage, sometimes our actual manufacture of pestilential vapours, all coupled with an exclusion of that supply of restless fresh air which is beneficently seeking entrance at every point, these dwellings of ours, even of the best class, only too readily become unwholesome; while in those of an inferior order, actual atmospheric poisoning is often the rule rather than the exception. The architect takes upon himself the responsibility of dealing scientifically, in the details of his plan, not only with "smells" and flagrant want of ventilation, but with a demand for brightness, airiness, proper aspect for sunshine, even prospect for cheerfulness—in short, all the environment, within and without, upon whose wholesomeness in one way or another healthy occupancy depends. Salubrity thus becomes a question of plan; and if close and stuffy rooms are generally avoidable by ordinary ventilation from the open air, and by cleanliness within (especially as regards upholstery), stuffy passages and staircases may no less be avoided by a careful consideration on paper of the facilities for producing air-currents (not necessarily draughts) by means of windows, or, where necessary, ventilated sky-lights. Damp, again, must be provided against, and the ascent of ground-air. In the case of sunk basements, nature's advice to us manifestly is to avoid altogether having habitable rooms underground; but where this cannot be done let particular care be taken to provide for atmospheric circulation under wood floors and through closed places; for the unwholesome air confined in the ground will force its way up into the warm house if it can—even through stone paving or a concrete covering. It is a good thing, also, to form emergency flues in the walls, to be turned to account if necessary.

Site.—It is no less injudicious to build our dwellings anywhere than to design them anyhow. In the open country, whether it be a stately mansion or a humble cottage, or, more usually, a comfortable family home, the situation of the house is most important. Where freedom of choice is unrestricted, let first the front containing the entrance, secondly that containing the garden windows, and thirdly the offices, be so planned separately as leading features, that never on any account can they be confused together. On the contrary, so dispose them that each façade of the house shall serve effectually by itself its own proper purpose—the entrance-front that of convenient ingress and egress, the garden-front that of bright and cheerful family privacy, and the offices-front that of the special operative department to which it pertains. For instance, it is quite inadmissible for the carriage-drive to pass through or along the lawn; or for the tradesmen's carts to use the principal approach; or for the kitchen-entrance to be in sight of the family rooms; or for the lawn or garden to be overlooked by the servants. Even in very modest dwellings something like a recognition of these elementary rules may be observed. To a considerable extent also in towns the same principles may be applied. Fig. 1 shows an example of typical treatment for a suburban house of good size.

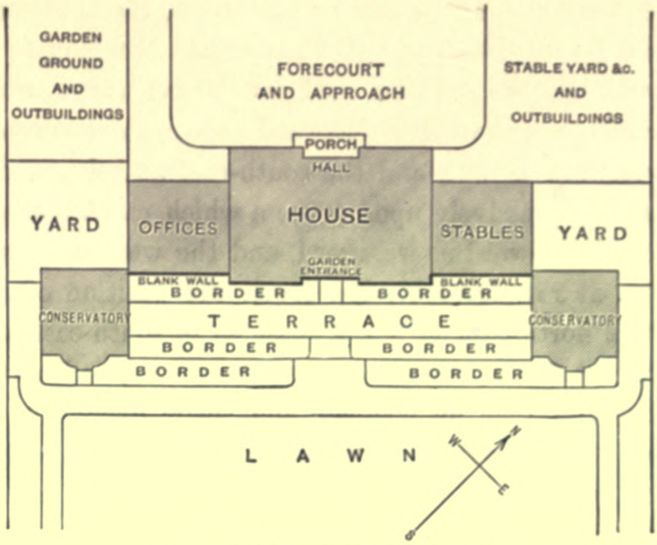

Fig. 1.—Site Arrangement: Suburban Type.

Aspect and Prospect.—It is astonishing that so few people consider the question of aspect. That of prospect or agreeable outlook is not generally neglected; but the elementary fact that aspect, or the influence of the weather and sunshine upon the house within, is of paramount importance, seems to be almost unknown. The aspect-compass here introduced (fig. 2) may be usefully studied. All the year round and everywhere in our hemisphere the sun is south at noon, and sunrise and sunset always at about equal distances therefrom eastward and westward; the sunshine lasting from about 6 A.M. till 6 P.M. (12 hours) at the March

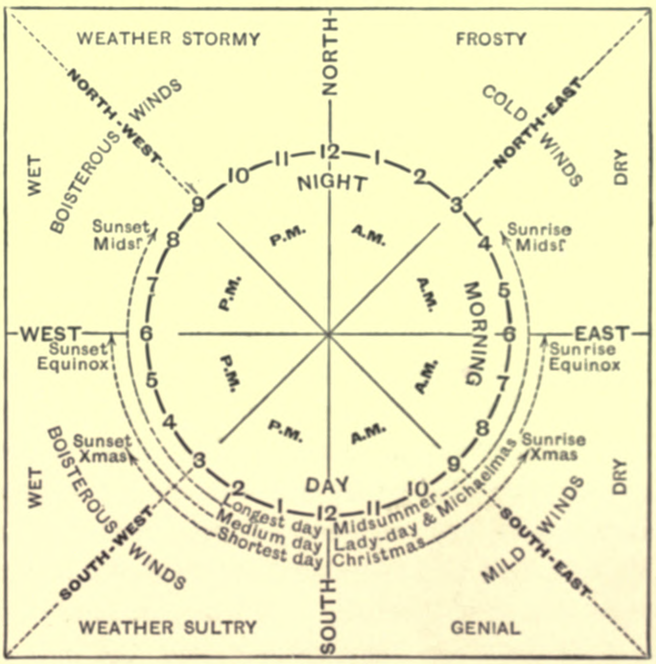

Fig. 2.—Aspect Compass.

and September quarter-days or equinoxes; from about 8 A.M. till 4 P.M. (8 hours) at Midwinter or Christmas, the shortest day; and from about 4 A.M. till 8 P.M. (16 hours) at Midsummer, the longest day. In our country, northward aspects are cold, and southward warm; the north-eastward catches cold winds, and the north-westward and south-westward boisterous winds; the south-westward is wet, and the south-eastward dry and mild. Sultry weather tells most oppressively upon a room which catches the afternoon sunshine by facing south-westward or westward, and the westward sunshine coming into a room is also at a disagreeably low level; the position of the sun being of course in all cases north-east at 3 A.M., east at 6, south-east at 9, south at 12 noon, south-west at 3 P.M., west at 6, north-west at 9, and north at 12 midnight. It follows, therefore, that for coolness and shade generally, windows should look more or less northward; for the morning sunshine, eastward; for mid-day sunshine, southward; for evening sunshine (or the sunset-prospect), westward; for morning coolness, westward; and for evening coolness, eastward; and the best compromise to suit most purposes is the south-eastward. We must remember, too, that sunshine in itself is an important health-agent, and the house may be so arranged that the principal rooms shall be well "sunned" in the early part of the day, and left to cool afterwards in such a way as shall be convenient and comfortable to the inmates. For instance, to be obliged to keep the window-blinds of certain rooms drawn down almost all day long, or to have other rooms insufferably stuffy in the afternoon although the sunshine is off the windows, is obviously an unfortunate state of things.

Light and Air.—This phrase is in very common use in England with a somewhat special meaning, owing to the law of "ancient lights", under which a building owner A is obliged to avoid interfering with the windows of his neighbour B as regards the access of light over A's property when this has been enjoyed for twenty years; the access of air also being held to go with the access of light. But, apart from this, it is obviously essential to the comfort, convenience, and salubrity of any dwelling, that the designer should particularly keep in view two elementary and self-evident maxims, namely, that every room, passage, and stair, and every corner in the house, should be not only lighted, but as far as possible abundantly lighted, and that any unavoidable compromises should be carefully and even anxiously adjusted; and further, that the inlet of fresh air from without, and the outlet of vitiated air from within, should be left as free as possible for the operation of kind Nature's fundamental desire to bring down the one by gentle force to every spot where it is wanted, and to bear the other upward and away. It is true that the human structure is endowed with a wonderful measure of endurance against darkness and suffocation, but it is the architect's duty that the presence of these baleful influences shall not be due to him. He must therefore take every care that his windows shall be, both in position and size, quite adequate to the work they have to do; not extravagantly large (because of the consequent heat and cold), but sufficiently large, and also judiciously placed; in fact, the window design of a dwelling is so far the light and air of the dwelling, and greatly affects its salubrity.

Spaciousness and Compactness.—To accomplish economy of space, and yet avoid cramping the plan, is of course a work of skill, and a result to be greatly commended. For compactness in most cases means both convenience and comfort, and a rambling arrangement inconvenience and discomfort. At the same time, the element of spaciousness or general roominess may certainly be coupled with that of compactness without any real sacrifice; while, on the other hand, confined and narrowed arrangements in detail may often be found associated with a disjointed and wasteful general plan.

Elegance.—Nothing has to be said here in the way of advocating mere elegance of proportions or artistic style as a consideration in the design of the plan of a dwelling; but what is worthy of remark is that the enthusiasm for fine-art has been somewhat too apt at times to compromise the utilities of house-building. Surface-embellishments may be lavishly employed in the interior without being complained of, but when the elementary conveniences of home-life are sacrificed to the fanciful demands of a fashionable archæological mode, objection surely may be raised. Fashionable Greek and fashionable Gothic having now both had their day, we may safely allude to the fact that they were both uncomfortable; and we may add that when an architect, who wishes to be in the fashion now, feels bound to insist upon having small windows purposely obscured, or upon introducing picturesque little flights of steps where no steps should be, his client need not hesitate to request, with all respect for genius, that he would be so obliging as to reserve such amenities for some more appreciative client.

Style of Plan.—There is a perfectly legitimate offer of choice in respect of the general plan of a house. That is to say, it may be laid out on principles of picturesqueness, quaintness, irregularity, and surprise; or on principles of regularity, symmetry, and repose. It is enough to add that some people prefer the one style, and some the other, as matter of sentiment; and that comfort, convenience, and salubrity may be fully achieved in either; subject only to this consideration, that even stateliness may have its drawbacks, as eccentricity unquestionably has. For good ordinary middle-class residences, the simple "square house" plan, so generally adopted by the last generation, is abundantly exemplified in suburban localities all over the country, with its central entrance-porch, hall, and staircase, dining-room and offices on one side, and drawing-room, &c., on the other. The manifest advantages here are symmetry, simplicity, and compactness. But the present generation prefers greater freedom of arrangement, the rooms must be disposed more independently, declining the restraints of symmetry, and the grouping may go as it pleases. The benefits of liberty are still evident, but we have to guard against equally obvious temptations.

CHAPTER II.

LIVING-ROOMS, BEDROOMS, AND THOROUGHFARES.

Thoroughfares.—The work of planning a house as a whole may almost be said to begin with laying out such a framework of thoroughfares—that is to say, entrances, passages, and staircases—as shall conveniently and appropriately accommodate the internal traffic, and place every apartment in its proper relation to all the rest. Although every room taken alone may be perfectly planned and perfectly furnishable on the proper principles, yet if this grouping of them all has not been satisfactorily accomplished, the house must be pronounced radically imperfect. Compromise may enter, and always does enter, into the adjustment of conflicting arrangements in detail, but it ought to be confined to a minimum, and a perfectly convenient and comfortable house possesses, as a first principle, perfectly convenient and comfortable thoroughfares.

In a typical house (say in the country) there ought to be certain arterial lines of thoroughfare clearly distinguishable. The first, on the ground-floor, leads from the front entrance through the hall, through or past the staircase, to the garden door. A secondary line branches off from this through the offices and by the back stair to the servants' entrance. The first accommodates the family traffic, the second that of the service. Upstairs the family traffic proceeds from the staircase to the bedrooms and dressing-rooms in succession, the nurseries, the bath-rooms and closets, and terminates at the back stair; and the servants' bedrooms have their own line of access commencing there.

One of the very chief considerations is the lighting; semi-dark passages and staircases are inexcusable, however common they may unfortunately be. In the country, where the site is free and open, defective lighting ought to be impossible; but even in the town, professional skill need never be so unequal to the occasion as to be satisfied with a dark passage or a blind stair, any more than with a dismal drawing-room or a gloomy kitchen.

The **entrance-hall** is too often treated as only a vestibule, but it is properly a rendezvous, and even in street houses space is well expended in making it as commodious as possible.

A staircase is most important as a chief thoroughfare. Airiness and good lighting by wall-windows, and not by a sky-light in the roof, are indispensable if the comfort of the house is to be assured. Winders or "turnsteps" should be avoided if it be possible; and the shallower the riser the broader must be the tread, so as to keep the stride nearly equal. In small houses a staircase readily carries an odour upwards, notably the smell of cooking. Odd steps in unusual places are an insufferable blemish in any plan. Again, it is an elementary rule never to introduce single steps anywhere—let there be two steps or none—except at an outside door, where the single step is used for the special purpose of keeping off the outside wet and dirt. Another elementary rule is to have no step or steps at the door of any room.

Living-rooms.—In a house suitable for an unpretentious family of the middle class, the primary living-rooms are a dining-room for meals, a drawing-room for the ladies, and a supplementary apartment for the master of the house, usually taking the name of "library" or "study". As the establishment advances in rank, a more proper library is substituted for the last, to accommodate gentlemen-guests and visitors; after which a billiard-room, a gentleman's room or "business-room" for the master's privacy, a subsidiary drawing-room called the "morning-room" for the ladies, and a boudoir or private room for the mistress, are successively provided, and sometimes a subsidiary dining-room called the "breakfast-room". On the other hand, in dwellings of less degree the dining-room is used as the general sitting-room, and the drawing-room chiefly for the reception of visitors, while the supplementary room, if any, is occupied according to circumstances—sometimes as a children's room. In still simpler households the dining-room becomes the family parlour, and the drawing-room, if retained, is only the best parlour for occasions of ceremony.

In all these rooms alike, there are three leading features in the plan, namely, the fireplace, the one or more windows, and the door; and, speaking generally, the fireplace is best placed in the middle of one of the sides of the room, the window or windows in the middle of either of the two sides at right angles to this, and the door in either of the two remaining walls close to that corner which is most removed from both fireplace and window (see fig. 3). Whenever possible, the fireplace should be against an internal wall, as smoky chimneys are particularly to be feared in external walls, because of the effect of atmospheric cold on the flue; indeed even tall chimney-stacks are liable to produce the same result. Keeping in mind this general type for simple plans, there need be no difficulty in dealing with more complex cases.

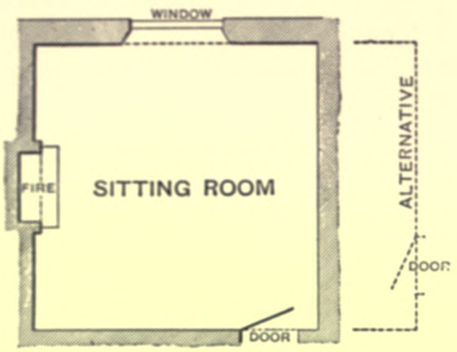

Fig. 3.—Sitting-room: Primary Type.

Figs. 4 and 5 show two very objectionable plans, one of a sitting-room and one of a kitchen, actually carried into execution to meet the exigencies of "style". In both cases the relation of the door to the fireplace could not be worse.

In **a dining-room** there is a fourth radical feature, namely, the sideboard; and, whether fixed or movable, it ought to stand opposite the fireplace. Then the mistress of the house is properly seated with her back to the fireplace, at

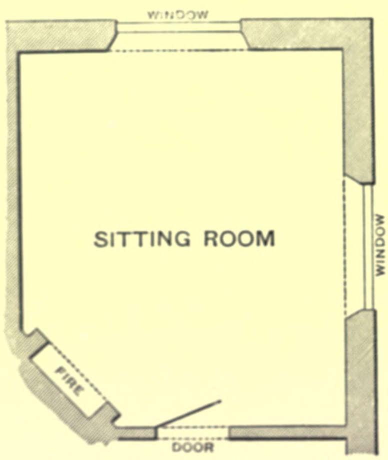

Fig. 4.—Sitting-room: Bad Example.

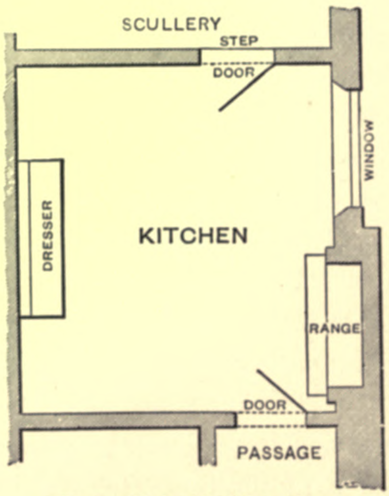

Fig. 5.—Kitchen: Bad Example.

the "head" of the table; and the master with his back to the sideboard, at the "foot" of the table; the origin of the latter arrangement being that the master is supposed to be in touch with the butler and the wine. The fireplace and the sideboard ought therefore to be placed on the end walls of the usual oblong room rather than on the longer side walls. The door is then to be placed at the sideboard corner in the wall opposite the windows, rather than in the sideboard end wall; but if there be a second door for service, this may of course be at the further end of the sideboard wall (see fig. 6). The furniture is marked on this plan, and need not be further described.

A drawing-room may be planned according to fancy, provided that the fireside is disposed in pursuance of the rule of comfort, and the door or doors rightly placed with relation to it; in other respects even a fantastic arrangement, within rational limits, becomes permissible; the only vital objection to this license being that all eccentric things, however pleasing at first, soon pall upon the taste. The aspect of a drawing-room ought to be south-east, and the prospect pleasant. The furnishing is matter of decoration in great variety.

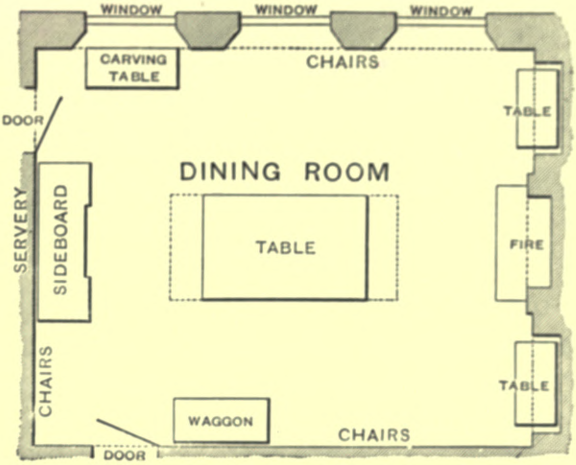

Fig. 6.—Typical Dining-room.

A morning-room ought to be a simply-designed apartment for the commonplace purposes of unceremonious feminine home-life, the license of eccentricity and the burden of restraint being alike out of place. Here again the aspect ought to be south-east or a little more eastward, and there should be a ready outlet to the lawn, perhaps by a casement-window. A comfortable fireside is essential, and suitable places should be provided for a writing-table and for work-tables; also a good position for a piano.

A boudoir is similar to the morning-room, but on the principle and scale of a strictly private instead of a more public room; it is also practically the mistress's business-room, from which the household management is directed, and a particularly methodical lady may have a sort of office-table or escritoire for a conspicuous feature. Otherwise it may be merely a very dainty retreat for refined seclusion, with a minimum of business; and sometimes it will be on the bedroom floor of the house, in which case it ought to be of very easy access from the principal staircase. The aspect and prospect ought both to be of the best.

A gentleman's room is, so far as privacy goes, like the boudoir, but of a thoroughly masculine and more business-like order. On a country estate it is, in fact, the estate-office, and may have a clerk's room attached. A professional man will perhaps make it in like manner purely a business-room. The aspect is preferably in the shade, say north-eastward. The access ought to be of twofold convenience, in the first place for visitors of importance entering the house by the front door, and in the second place for others who come through the servants' offices.

A library, properly so called, is of course a book-room, surrounded more or less with book-cases, and furnished with reading and writing appliances and very comfortable chairs, &c. In good houses it is the gentlemen's public morning-room or lounge. An eastward aspect is desirable, and the lighting is important. A study or small library is frequently a problem of some difficulty. Fig. 7 represents a good model; the occupant sits with the fire-place at one side and the light at his left hand; his book-cases also are well lighted, the door is as it ought to be, and he has a good place for a side-table, an easy-chair for a visitor, and a pleasant fireside.

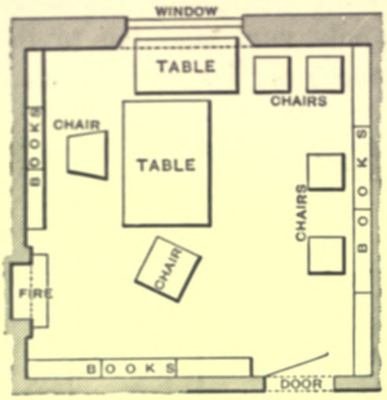

Fig. 7.—Typical Study.

A billiard-room is not a thing to be planned anyhow if it is to withstand the criticism of even the least-accomplished players. The table, twelve feet by six, ought to have a space of six feet or more all round it; and the lighting ought to be by a ceiling-light immediately over the table and of the same dimensions; wall-windows may be used when better cannot be had, but at best they are only a make-shift. When, as is perhaps most frequently the case, the billiard-room is used as a lounge for gentlemen, there ought to be a comfortable fireside at one end, with sufficient extra floor-space. It is important that a billiard-room should be well ventilated artificially. The well-known three pairs of strong hot lights for evening use render this especially necessary; more particularly if the room is to be used as a lounge during the day, and perhaps as a smoking-room, and still more if ladies are to play after dinner or to look on with comfort.

A smoking-room, if so called, is, more properly speaking, a free-and-easy lounge where smoking may be carried to excess without the risk of offence, and which may be confidently used for any casual masculine purpose.

A parlour, or unpretending family living-room taking the place of the more formal dining-room, is primarily a sitting-room, having a good fireside at one end and a sideboard at the other, a table in the centre for meals and all other purposes, a pair of easy-chairs, a couch, and the usual miscellaneous furniture. If there be a second or best parlour, so called, it will be simply a somewhat superior room of the same type, taking the place of a drawing-room.

A breakfast-room in a good house is a subsidiary dining-room, similarly furnished, but in a more homely style, and used by the family for breakfast. It is placed somewhat eastward accordingly, and is available for children's meals, and perhaps for parlour purposes at pleasure. In London houses of modest pretensions the front basement-room is often the breakfast-room, the kitchen being conveniently situated immediately behind it.

A conservatory as an adjunct to the house may be best described as a glass room attached to the ladies' quarter; preferably to the hall, staircase, or garden entrance; never too directly connected with any of the family apartments (because of the moistened air); calculated for only a moderate temperature; and, of course, sufficiently exposed to the sunshine. The less crowded it is, and the more like an elegant lounge, the better. The plants are its garniture more than its mere contents.

Bedrooms.—Every person who has experienced the satisfaction of occupying a thoroughly comfortable bedroom must have seen how much its proper arrangement, whether as regards the planning of the room itself or the disposition of the furniture, becomes identified with its comfort. On the other hand, there are few who can have failed to observe that in too many bedrooms there is something wanting; in fact, that the plan of the room has been very much left to chance, and the disposition of the furniture to the ingenuity of the mistress of the house, often under considerable difficulties. It is true that the bedroom-floor of a house, as a whole, has to follow the lead of the ground-floor, and no less that the principles of plan of the two storeys and their requirements may not correspond. Compromise, therefore, must then of necessity enter into the solution of the secondary problem; that is to say, wherever the living-rooms below and the sleeping-rooms above are at variance, it is the sleeping-rooms that must give way. But it does not by any means follow that the bedrooms are to be negligently dealt with; on the contrary, the earnest designer must devote all the more trouble to them.

A bedroom, just as much as a living-room, ought to be planned within itself, or strictly upon internal conditions; and it is most essential that the furniture should be plotted on the drawing. The governing features are not only the one or more windows, the one or more doors, and the fireplace, but obviously the bedstead, the dressing-table, the wash-stand, and the wardrobe; and the problem of plan is to find a proper place for each in relation to all.

The standard bedroom is one for the accommodation of a married couple. It is the custom for the lady to use it also for dressing, a small adjoining dressing-room being provided for the gentleman. In planning an ordinary or typical suite of this kind in the simplest form, and taking the bedroom first, the window may be considered as a fixed point. Whether to place the bedstead opposite the window, or against one of the other walls, then becomes a sort of personal question; for some people when in bed object to a glare at the foot, while some have the same objection to a glare at the side. The fireplace will preferably be in the middle of one of the other walls, and the wardrobe in the middle of the remaining one. The dressing-table then is placed against the window, and the wash-stand preferably towards one corner well in the light, and there is another corner for a chest of drawers. As regards **the dressing-room**, the first thing to bear in mind is that there must be a place for an emergency bedstead, probably, if the room be small, in the corner away from the window. The fireplace, wardrobe, and wash-stand may then be accommodated according to circumstances. The door of intercommunication with the bedroom ought to be removed from the outer door, and also from the fireplace. The dressing-table goes to the window.

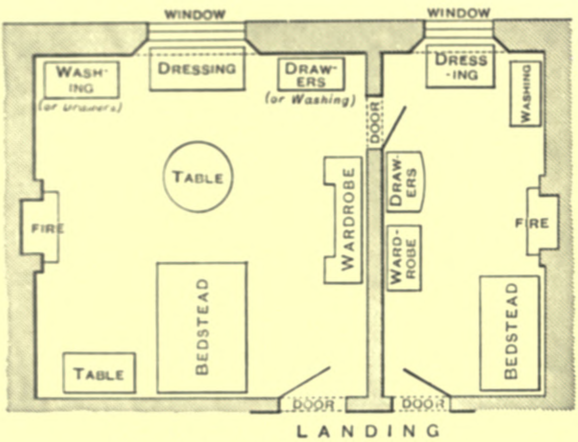

Fig. 8.—Typical Bedroom and Dressing-room.

Several illustrations must be given under this important head. Fig. 8 represents a good standard arrangement when the rooms are sufficiently large. In the bedroom the bedstead is placed with its foot to the light, standing centrally against the wall, and the wardrobe occupies a central position opposite a central fireplace. The outer door is in the position which is most usually accepted, but one which has an obvious disadvantage in relation to the bedstead, although it would undoubtedly be still more objectionably situated if in the wardrobe wall. The door to the dressing-room is conveniently situated for both sides. A centre table has frequently to be accommodated, but this involves no difficulty if the room be large enough; a bedside table is also shown. The wash-stand may be at either side of the window, and the chest of drawers at the other. Space must be left for a good fireside, which it is so often essential to maintain. Turning to the dressing-room, it will be seen how a good position for a bedstead becomes a primary consideration; the fireplace need not be central, the wardrobe and drawers are well in the light, and so is the wash-stand. Of course the arrangement as a whole admits of modification where the general plan of the house requires it.

Fig. 9 shows a similar plan for an ordinary street house on the well-known London model called "two rooms on a floor". The bedroom arrangements are the same as in the last instance, but in the smaller apartment in the rear, shown as the dressing-room, a little difficulty arises as to the place for the bedstead. There are three alternatives. Firstly, it may be put in the inner corner opposite the door of entrance (as dotted); which may require the sacri-

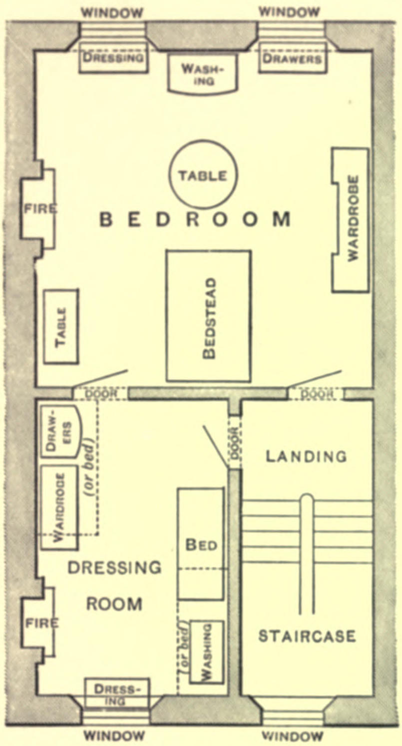

Fig. 9.—Bedroom and Dressing-room in Street House.

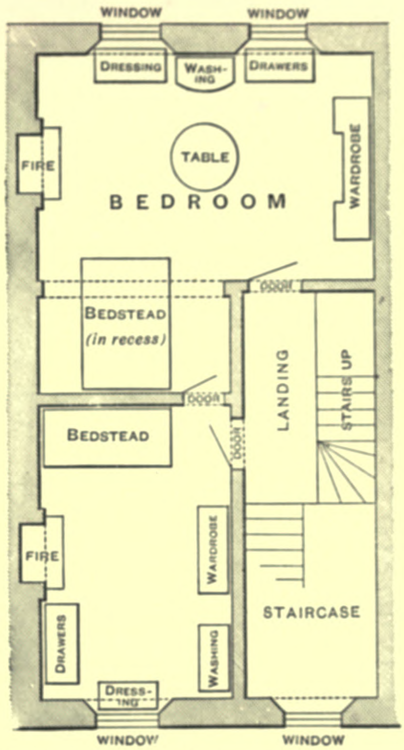

Fig. 10.—Bedroom with Recess, and Dressing-room

fice of the door of intercommunication. Secondly, it may be put in the corner next the window (as also dotted); which raises the question of a draught. Thirdly, it may be placed, as here represented, against the middle of the staircase wall, and the sleeper may make either end the head as he pleases. The wardrobe gives no difficulty; and the fireplace in any case need not have a central position.

Fig. 10 represents an arrangement for a street house, which has certain advantages. The stair-landing being extended to accommodate a separate flight for the storey above, leaving the space over the main staircase free for a room, the bedroom becomes L-shaped, so that the bedstead stands in an alcove secluded from the door. The dressing-room bedstead then occupies an inner corner sideways to the light, the door of communication has a suitable place, and the fireplace may be central.

Fig. 11 shows the bedstead standing sideways to the light (but exposed to the door), the fireplace is central opposite, and the dressing-room has its two doors, its bedstead well placed, and its fireplace central. Otherwise this bedstead may be in the corner, and the fireplace out of the centre.

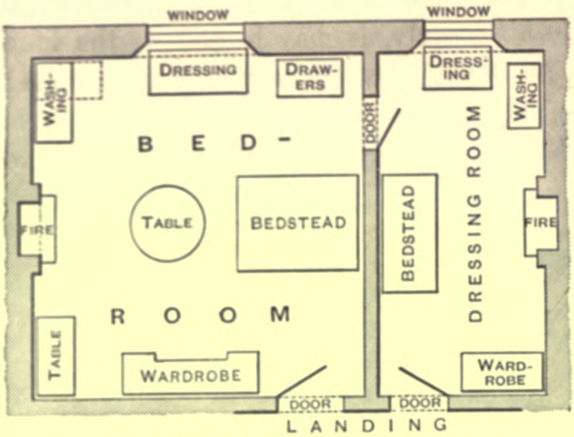

Fig. 11.—Bedroom and Dressing-room. Alternative to Fig. 8.

A sort of French bedroom or **bed sitting-room,** especially suitable for young ladies, is represented by fig. 12. It has a bed-alcove, which may be screened off during the day by a *portière*; the two side closets serve for washing and dressing respectively, and the main area of the room is free from all sleeping-room furniture except a wardrobe and probably a cheval glass.

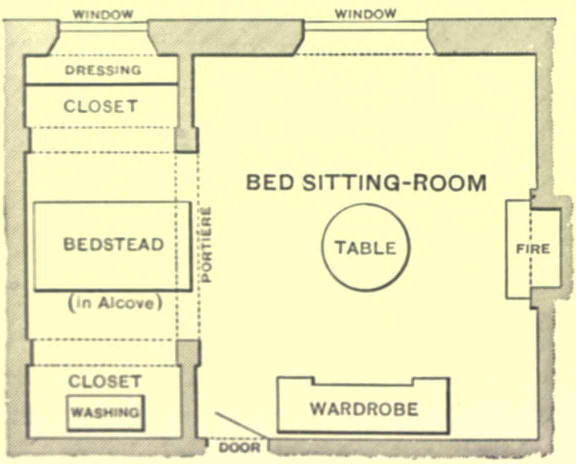

Fig. 12.—Bed Sitting-room, with Alcove.

In cases where dressing-rooms must be dispensed with, and the bedrooms themselves are of diminished size, the principles above indicated ought to be followed out as best may be, but in no case is it excusable to pass such a room on the paper plan until the bedstead, window, door, and fireplace have all been plotted thereon in a sufficiently satisfactory relation to each other.

On the other hand, a **bed-chamber suite** on a superior scale is perhaps all the more easily designed. It is simply a group of rooms, comprising a bedroom, two dressing-rooms, perhaps the boudoir besides, a wardrobe-room, a bath-room, a water-closet, and, for access to the whole, a lobby or corridor with its own private door. The general principles of arrangement are still the same.

Every bedroom of sufficient size ought to be designed with an eye to the chances of occupation by an invalid; and in many cases of even the most temporary illness it may be found extremely desirable to have a second room in communication, available for the nurse's work. The ordinary dressing-room will suffice. A door towards an adjacent bedroom is objectionable.

Children's rooms have to be specially designed. In very complete form these will constitute a suite, comprising a night-nursery, a day-nursery, a nurse's private room, a private corridor with its own outer door, a bath-room, a water-closet, a wardrobe-room, and perhaps a little scullery. The night-nursery ought to be carefully planned so as to accommodate a sufficient number of little bedsteads kept clear of draughts, with a comfortable fireside and plenty of light and air. The day-nursery also must have a good fireside, and be well lighted and ventilated; and the furnishing will probably have for its basis a large square central table for elementary school-work, &c. The subsidiary apartments are easily designed. In a permanent family residence the necessity for a school-room ought to be kept in view, with a governess's room close at hand; and both of these, and the nurseries as well, ought to be available as ordinary bedrooms when not specially in use. Cupboards and closets are particularly useful for children's rooms; and there must be ready access for the mother at night.

CHAPTER III.

DOMESTIC OFFICES AND SUPPLEMENTARIES.

One characteristic of a well-planned house is that the family department and the servants' department are distinctly separated. It is not, as some might suppose, that allowance has to be made for class feeling as between superiors and inferiors; it is simply that the family desire to enjoy freedom from interruption, and that the servants have the same objection to be unduly disturbed or overlooked. In other words, there are two sections of the household both equally entitled to privacy so far as their relations to each other admit; and accordingly, the offices as a whole have always to be grouped together on the same principle, whether in a small house or in a large mansion. Of course there are classes of households in which no distinctions of social status have to be observed, in which case the separation in question may not come into view; but even then the principle need not be ignored.

The first in order of the domestic offices is **the kitchen**, and the leading feature of its plan is the cooking-range. This ought to occupy preferably a central position in one of the longer walls of the usual oblong room, and in front of it in the middle of the room there will be the large kitchen-table. The window-light ought to be on the left hand of the cook when engaged at the range, and the kitchen dresser ought to stand conveniently adjacent to the table. Miscellaneous apparatus is now manufactured in so much competing variety that it is mere matter for choice in the warehouse, and need not be described (see fig. 13). But the cook's closet must not be forgotten, in a handy position for constant access, and the door of entrance to the kitchen ought to be near one corner, and must not incommode either the fire or the traffic. **The scullery** is an apartment which ought to be directly connected with the kitchen, and the door between the two ought to be as near to the range as possible; to have to cross the kitchen to reach the scullery is very objectionable; to have to cross a passage outside is fatal. The scullery will have a fireplace containing a small supplementary range, one or two coppers or other boilers, and one or more sinks; and there must be a door of entrance besides the door of intercommunication with the kitchen. The light to both kitchen and scullery ought to be ample, with an aspect northward or eastward. Ventilation ought to be carefully provided for; if the work to be done is on a liberal scale it may be desirable to increase the height of the ceilings. An outside door in the scullery is often desirable, but not in the kitchen. In small establishments the principle of plan is the same as in large, the scale of the apparatus and accommodation being proportionately reduced. Fig. 13 shows a good arrangement of kitchen and scullery, with larder and pantry, and outside access or so-called "tradesmen's entrance". The kitchen corridor also is designed with a motive. The lobby at the out-

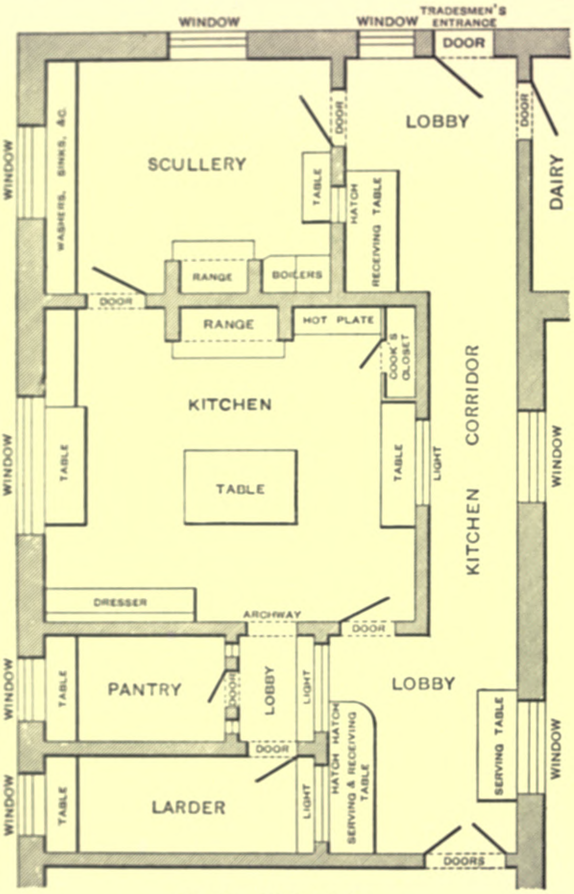

Fig. 13.—Kitchen Suite.

side door is made to accommodate a table for receiving supplies, and a similar table is provided in a special recess near the larder. The kitchen door is placed out of the line of the corridor traffic. An indication is likewise shown of the principle of inclosing when possible the corridor as a whole, and the borrowed lights throughout are chiefly for ventilation. Hatches for the scullery and the larder, as shown, are useful for taking in the supplies. The purpose of this illustration is chiefly to suggest a large number of convenient appliances, the distribution of which, and indeed their introduction, must depend upon circumstances.

It will be observed that the scullery is on one side of the kitchen, while **the larder and pantry** are on the other. The scullery is necessarily at times a somewhat uncleanly adjunct, while the larder (for uncooked meat) and the pantry (for cooked) must be carefully protected against any pollutive influence. Therefore to make these open out of the scullery is inadmissible. Bread and pastry, and perhaps milk and butter, are kept in the pantry, and vegetables and cured meat in the larder; but no special provision need be made in either case. When **a dairy** is required, it ought to be so far separated from the kitchen offices as to be kept fastidiously clean and cool; and the work of cleansing the dishes ought to be easily taken therefrom to the scullery, or to the open air. All these offices must have a cool aspect.

When the domestic offices occupy a **sunk basement,** there are special difficulties to be contended with as to lighting and ventilation. Dark passages and a dimly-lighted stair are frequently found even in good houses. Wide open areas, extending as far as possible, are the best substitute, although by no means an equivalent, for the open air; and ventilating flues in the walls may be made very useful. Sleeping-rooms in a basement are not to be sanctioned.

The butler's pantry demands a peculiar position. It must primarily be close to the dining-room; and it has no connection with the kitchen-department, except for service. It has also to be conveniently situated for attending to the entrance-hall, and likewise for commanding the back entrance, although it must not be easily accessible to the light-fingered class. There may be a plate-closet or safe attached to it, and sometimes there is also a little private scullery for the cleaning. The butler's bedroom is a necessary adjunct in large houses for the protection of the plate.

The servery is an appendage at the sideboard end of the dining-room, in fact an anteroom towards the butler's pantry. In small houses the service has to take place from the corridor, and very frequently through the only door of the dining-room; in which case it is always desirable to provide space for a serving-table outside the room. In superior houses the servery may require an ordinary hot closet, for the purpose, so often hopeless, of keeping a ceremonious dinner warm. When a kitchen of importance has to be in the basement story, there ought to be a dinner-lift, but not opening actually into the dining-room.

The housekeeper's room in large establishments is the sitting-room and business-room of the housekeeper, and the dining-room of the upper servants; the lady also is enabled to give her directions there. In smaller houses where there is no separate housekeeper, it may still keep the name—or preferably that of housekeeping-room—and be a business-room and special store-room, and even a working-room for a thrifty mistress. In either case, the leading feature is the series of closets or cupboards which contain the groceries and dainties, china, glass, and table-linen in use. In yet smaller houses **the store-room** takes its place; while in larger houses there will be a store-room besides the housekeeper's room, taking the supplies of chandlery and the like. Sometimes a **china-closet** may be provided for the purpose implied by the name, and occasionally a **still-room** for making the tea and coffee &c. All these offices ought to be well lighted, if only to avoid breakages and confusion.

The servants' hall is the living-room for the lower servants,—or for all, if few in number,—used for their meals and evening accommodation, also for miscellaneous work, and for the reception of visitors' servants and other persons of the same rank; the housekeeper's room and the butler's pantry being similarly utilized in their own way. In small houses the kitchen has to serve for all such purposes, supplemented by the housekeeping-room if there be one. A typical servants' hall ought to be situated near the back entrance, also near the kitchen for service of meals, and sufficiently near the butler's pantry. It ought to have a comfortable fireside, and be cheerfully lighted.

A "**maid's pantry**" is the name often given to a butler's pantry on a minor scale where no men-servants are kept. **A housemaid's closet** however, is a small place on the bedroom floor, containing a sink and accommodation for brushes, dusters, pails, cans, and so on, with water-supply. It ought to be placed near the back stair if there be one, and at any rate in a sufficiently sheltered position. **A brushing-room** is a small place in a superior house for brushing garments. **A lamp-room** in a country house is a place for keeping and lighting the lamps; not a cleanly place, although not to be kept dirty.

A laundry suite in a country or suburban house is a special set of offices consisting of a wash-house, a laundry, perhaps a hot drying-closet, and perhaps a closet for soiled linen, with a drying-ground attached. The whole group ought to be kept well-separated from the bulk of the house for obvious reasons, with abundant light and air. The fittings are well known.

A linen-room is a small place amongst the bedrooms in which the stock of bed-linen may be kept, and perhaps table-linen for convenience. Dryness is here especially desirable, and the hot-water piping of a bath-room may be carried through it with advantage, even if it be only a cupboard.

A bath-room is now recognized as an indispensable supplementary in every house above a certain standard of moderate importance, and in larger houses several are required. Even in small suites of residential rooms such as are called "flats", and sometimes, indeed, in the ordinary bedroom-suites of family residences, a separate bath-room is provided. It is generally a small place, containing a reclining bath and little else; but if to be used by persons who must dress there, not only a wash-stand and a dressing-table, but a fireplace or gas-stove may be required. A water-closet ought to be accessible.

A lavatory is a wash-hand room for gentlemen, attached to the cloak-room of a good house, or very generally incorporated with it. It is simply provided with one or more wash-basins, towel and pin-rails, and a dressing-table; and the light must be duly considered. A water-closet is usually attached. The proper position is near the entrance-hall, so that visitors may have access to it; and a fire-place is desirable in important cases, if only for occasionally drying a garment. Fig. 14 represents a convenient arrangement.

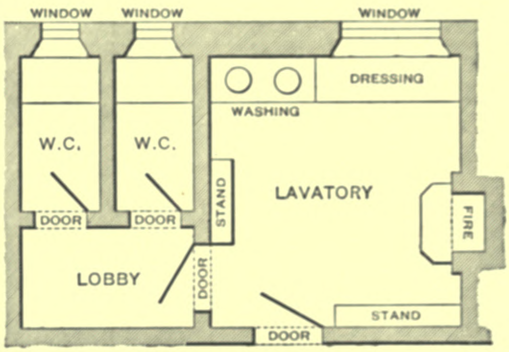

Fig. 14.—Lavatory and Closets.

The English **water-closet** with its sanitary apparatus is an institution of world-wide repute. The common faults of plan which have to be avoided are these:—It ought not to be insufficiently lighted, and certainly not inadequately ventilated; it ought not to be placed anywhere that may happen to offer, but invariably against an external wall; and especially ought the risk of flooding some important ceiling beneath to be avoided. Unquestionably the best plan is to place all water-closets, bath-rooms, housemaids' sinks, and wash and water places of every kind, one over another by themselves, so that in case of accident they shall only damage each other, and also so that the plumber shall be able to work his will without disturbing the house at large.

The question of the number of water-closets required for an average house stands thus. In any case there will be one for the servants and one for the family. In larger houses one will be provided on the ground-floor for the use of gentlemen, and one or more for the bedrooms upstairs; then special ones for bedroom suites, nurseries, cloak-room, bath-rooms, billiard-room, school-room, business-room, and so on, as the establishment expands; and when the house is large enough, the servants of each sex have to be separately provided with a sufficiency properly distributed. The rules for position may be stated thus:—The English feeling of delicacy dictates privacy throughout, and therefore

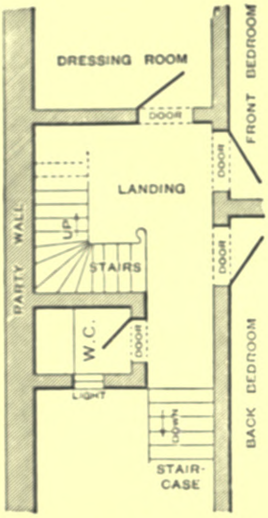

Fig. 15.—Internal Water-closet: Bad Example.

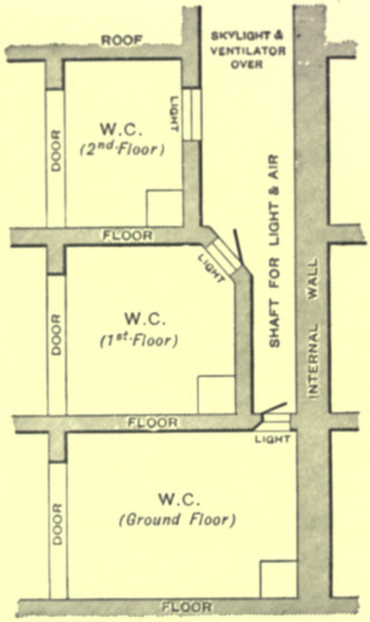

Fig. 16.—Internal Water-closets in Vertical Series: Bad Example.

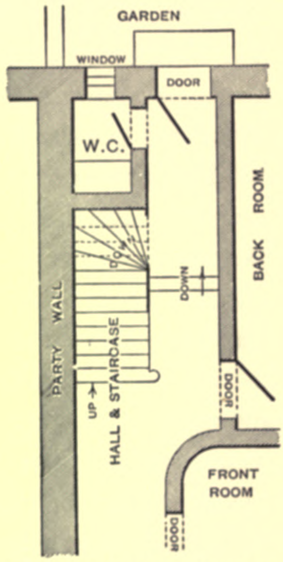

Fig. 17.—Water-closet at Garden Door: Bad Example.

the principal thoroughfares of the house must be avoided as much as possible; in every case there ought to be a window in an external wall; sky-lights are objectionable; well-holes or interior lighting-shafts are worse; and borrowed lights are not to be thought of.

Fig. 15 represents one form of an arrangement which still prevails in some of the highly-rented neighbourhoods of London; it is difficult to imagine a more objectionable make-shift. The staircase-landing adjoining the principal bedrooms is partly appropriated to the water-closet, which thus occupies a position in the very midst of the house; and the object of so placing it is to get a borrowed light (on hinges) towards the staircase as the nearest equivalent for the open air.

Another mistakenly ingenious plan is shown in fig. 16. Several closets are placed in the interior of the house one above another, and a small shaft is formed at the back, increasing in size to a sky-light in the roof, so as to afford such light and ventilation to them all as can be gained by means of small hinged sashes over the seats. The arrangements shown in figs. 15 and 16 appear to have been devised in order to avoid occupying part of some external wall with the windows, which were considered an eyesore, but more modern planning gets over the difficulty in other ways.

The very common custom, in medium-sized houses, of putting a water-closet under the stair at the door which leads to the garden in the rear, shown in fig. 17, is so objectionable in several respects that argument upon it is needless.

The dust-bin or ash-pit is capable of being made either a nuisance or not, and even its precise situation becomes in most cases a matter for careful consideration. It ought to be far removed from all windows, and all that the designer of a plan can possibly do in the direction of avoiding air-pollution and facilitating cleanliness must be done. Is it too much to suggest that a few glazed bricks might effect a great improvement?

CHAPTER IV.

MISCELLANEOUS HOUSES.

Cottages.—The simple home of the humble family need not be carelessly planned. Even a two-room cabin whose doors, windows, and fireplaces are all in proper relation to each other, is quite a different thing from one in which these are disposed at random. The faults to be avoided are such as the comfortless fireside, cheerless lighting, uncleanly adjuncts, inconvenient sleeping-rooms, a dark stair, and the want of cupboard accommodation; and little else need be said. When the so-called cottage becomes amplified into a middle-class residence, there is of course a little less restraint, and that is all.

Flats.—This popular name applies to the bulky edifices which of late years have been built for the accommodation of townspeople who for various reasons object to take entire houses and yet do not care to occupy mere lodgings. The best of them are now coming to be called "mansions", and in many cases they are designed and furnished with no little magnificence. The principle of plan is no more than this:—each successive story of the building is divided into two or more self-enclosed tenements, with access only from a common staircase.

This arrangement is common on the Continent, and has long been adopted, without pretension, in the cities of Scotland—where the local term "flats" signifies floors. The tenant of a flat, entering by his own private door on the public staircase-landing (which in some cases he reaches by a lift), finds himself in a private corridor leading to his several rooms—all of course on the same level—perhaps two or three in number, perhaps six or eight. The plan is simple; sometimes only a sitting-room, a bedroom, and a bath-room and closet; sometimes dining and drawing rooms and several bedrooms; sometimes a kitchen &c. There are two evils that suggest themselves:—firstly, the rooms are apt to be too small; secondly, the whole building, owing to its bulk and subdivision, may be deficient in both light and air.

Artizans' Dwellings.—These are what used to be called "model dwellings", and in the present form are simply "flats" for working-people's families. The planning of the several rooms—a living-room, one or two bedrooms, a little kitchen or scullery, a pantry, and a closet, with perhaps a balcony—follows the ordinary rules; and the two evils attaching to what may now be called a sort of barrack life have still to be faced, namely, straitened space, and deficient light and air.

Bungalows.—A one-floor house, with especial spaciousness and simplicity within, and the open country or the sea without, and a verandah, is considered to be of the nature of the Indian residence known by this name. Its plan with us is that of a "flat" very liberally treated, with a superabundance of light and air and the rules of aspect fully observed.

Other exceptional cases might be noticed, but it suffices to conclude with this observation:—Whatever speciality, or peculiarity, or even eccentricity, may have to be dealt with as a problem of house-planning, the elementary principles are in this country always the same, not only in theory but in practical working; the foremost of which, and the most uncompromising, are internal comfort, convenience, and salubrity, coupled with the advantages of genial aspect and the graces of intentional pleasantness as far as circumstances will allow. Nothing is here so insignificant, or so commonplace, as to be unworthy of the designer's most careful attention. We are a practical people, and this is a thoroughly practical matter.

SECTION II.

CONSTRUCTION

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SECTION II.—CONSTRUCTION.

CHAPTER I.

THE PROBLEM STATED AND DISCUSSED.

The healthfulness of a house depends to some extent on the geological formation on which it is built, its position and aspect, the nature of the water-supply, the density of the population around it, the climate and other external circumstances; but it also depends largely on the materials of which the building is constructed, and the manner in which these materials are employed. A house may be situated in a salubrious locality and may have a plentiful supply of pure water, and yet not be fit for occupation.

And the fault need not lie in the drains or the water-closets. These and the sinks and other fittings may be as perfect as can be, and yet the house be dangerous to live in. This fact is apt to be overlooked. Drainage has been so much written and talked about of late years, that every house-hunter nowadays asks at once, "Are the drains all right?" He does not ask, "Are the walls, the floors, the roof all right?" and yet these have an important influence on the healthfulness of a house. The ill effects of defective walls and floors and roofs may not be so quickly manifest as those of bad drains and nasty fittings, but they are no less certain and dangerous; rheumatism and diseases of the respiratory organs are frequently caused by cold, damp, dusty, draughty, or smoky and ill-ventilated houses, and even if these ailments are not produced, vitality is lowered and the occupants of the houses become an easy prey to other diseases. In fine, the general construction of a building, quite apart from all question of the site, water-supply, sanitary fittings, drainage, and ventilation, may be responsible for its unhealthiness.

A damp house, it has been well said, is a deadly house. But dampness is not the sole danger. **The model house** will not only be dry; it will also be of equable temperature, free (as far as possible) from dust and smoke and air-pollution of every kind, filled with light and sunshine, and adapted for cleanliness. It will be planned in such a way that no part of it will be close and stuffy, but every nook and corner receive an adequate supply of fresh air. Moreover, the model house will be reasonably safe from destruction by lightning and by fire.

1. *DRYNESS.*

Damp may enter a house from above, below, and from all sides. It may come through the foundations, floors, walls, roof, windows. It may be the result of ground-moisture or of moisture in the air, or may be caused by the back-flow of drains or by defective water-pipes and fittings. It is the cause of decay in wood, of rotting carpets, soiled wall-papers, swollen doors and drawers, dank smells, mildewed pictures and books, and even of smoky chimneys. Truly there are disadvantages in a damp house other than its unhealthiness.

To secure a dry house is sometimes difficult, but it is not usually impossible, provided funds do not run short. A few general rules may be laid down. They may be divided into two groups: the *first* consisting of those for the exclusion of ground-moisture, and the *second* for the exclusion of atmospheric moisture.

I. To Exclude Ground-moisture.

1. Drain the **subsoil.**
2. Lay over the whole excavated site under the lowest floor of the house an impervious **ground-layer,** as much as possible above the drainage-level of the ground.[1, 2]
3. Construct **cellars** under the whole building.
4. Let the **ground-floor** (*i.e.* the principal floor) be well above the external ground.[1]
5. Let every wall have a horizontal **damp-proof course** above the external ground and below the ground-floor. If the basement is for habitation, let there be another horizontal damp-proof course just under the floor-level, and connect the two with a vertical damp-proof course outside the wall; or form an **open area** to a depth of about

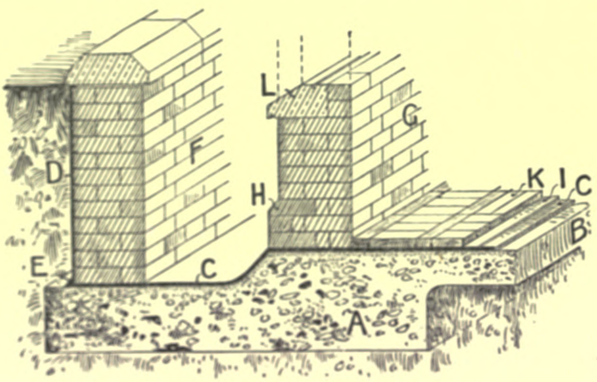


Fig. 18.—Concrete Ground-layer, Open Area, &c.

A, foundation of concrete alone; B, concrete ground-layer; C, horizontal asphalt damp-course; D, vertical asphalt damp-course; E, asphalt fillet; F, area-wall; G, house-wall; H, blue-brick plinth; I, mastic for wood-blocks; K, wood-block flooring; L, stone window-sill throated beneath, and grooved on top to receive weather-tongue.

[1] See Plate II. [2] See Fig. 18.

six inches below the basement floor.[1, 2] So-called "dry areas" are useful, but not always satisfactory.

6. Build the **walls** with materials as impervious to moisture as possible, taking particular care about the mortar and the flushing and grouting of the joints.

7. Pave and drain the **yards and paths** around the house, so that the rain-water may be removed quickly and effectually.[1]

II. To Exclude Atmospheric Moisture.

1. Build the **walls** with materials as impervious as possible, taking particular care about the mortar and the flushing of the joints; in special cases, hollow walls may be used, or a small vertical cavity may be formed and filled with impervious material.

2. Lay an asphalt **damp-proof course** under all parapets and gutters.[1]

3. Let all **window-sills** project and be throated under,[2] and all **cornices** and projections be weathered on the top, so that the moisture will not be conducted into the wall but thrown clear of it.

4. Let the **eaves and gables** of the roofs project a foot or more beyond the walls:[1] this is one of the best preventatives of damp bedroom walls; but if ordinary parapets or eaves-troughs, and stone-coped or brick-coped gables are desired, let not the plumber be stinted in his lead.

5. All **slates and tiles** should be of good quality and should have sufficient lap; where the money can be spared, they should be laid on boards covered with waterproof felt.

6. If **lead gutters** must be used, they must not be laid level and the drips omitted or reduced to an inch or so; let the fall be as much as possible and the drips at least two inches, and do not forget snow-boards.

7. **A straight roof** can more easily be made water-tight than a roof with valleys, openings, and projections. All valleys, sky-lights, dormers, chimneys, are possible sources of leakage.

8. Birds' nests are often beautiful, but a sparrow's feather-lined hayrick is out of place in the head of a **rain-water pipe**. It is wise to take away the temptation by preventing access to the pipe.

9. **Windows and doors** and other exposed woodwork should be strong, of good material and workmanship. Sash-windows are more easily made waterproof than casements, especially if the latter open inward; leaded lights, in exposed situations, almost invariably admit rain.

[1] See Plate II. [2] See Fig. 18.

10. Proper **warming and ventilation** are helps to dryness, because they prevent the condensation of moisture on walls. When the walls are built or faced with non-absorbent materials—whether cement, glazed ware, paint, or varnish—adequate warming and ventilation are indispensable for comfort. Ordinary walls, it is well known, "breathe", *i.e.* air passes to and fro through them, and a certain amount of moisture is in this way slowly removed from occupied rooms. That this is the case, may be easily seen in any house where some of the walls are painted and varnished, and some covered with ordinary unglazed paper pasted to common porous plaster; when the walls have been cooled by frost, or in cold weather by lack of fires for some days, a warm day covers the impervious wall with moisture, sufficient, perhaps, to trickle down in drops, while the absorbent wall shows little or no sign of dampness. The moisture contained in the warm air is condensed on the cold walls, and if it cannot find entrance, must remain till warming and ventilation remove it.

Damp, however, may be caused not only by moisture in the ground and air, but also by **defective water-pipes and fittings.** All water-pipes should be amply strong enough to resist the pressure to which they will be subjected, and must be carefully protected from frost. Safes and gutters should be provided where necessary, to take away the water in case of accident. It is surprising how long a small leak in a service-pipe or waste-pipe may pass undetected or unremedied.

2. *EQUABLE TEMPERATURE.*

A damp house is colder than a dry house, but a dry house is not necessarily of **equable temperature.** An iron building may be proof against the ingress of external moisture, but it will be cold in winter and hot in summer, for iron is a good conductor of heat. To prevent such extremes of temperature, iron churches are lined with wood, a material which conducts heat very slowly. A common illustration of the difference of the two materials in this respect is that of an iron poker and a wood brand, each with one end in a fire; the knob of the poker will sear the hand before the outer extremity of the wood becomes uncomfortably warm.

The **relative thermal conductivity** of different building-materials is, according to Péclet, approximately as follows:—Fir boards 1, plaster 2·8, brickwork 3·5, glass 4·8, stone 10, marble 18; and that of various metals used in building has been ascertained by Wiedemann and Franz to be as follows, silver being taken as the standard with a conductivity of 100:—Copper 73·6, brass 23·6, tin 14·5, iron 11·9, steel 11·6, lead 8·5. Water and air conduct heat only to a very small extent, air being one of the worst conductors known; hence Nature's devices of feathers, fur, and wool, and the human inventions of hollow walls, double windows, ceiled attics, silicate cotton, and cocoa-nut fibre packing.

The use of a bad conductor of heat in conjunction with a material which is a good conductor of heat but practically impervious to moisture, is exemplified not only in the lining of iron buildings with wood, but also in the boarding of roofs under slates or tiles. The **slates** and **tiles** are practically impervious to moisture, while the boards retard the ingress and egress of heat. In the case of roofs, however, it is necessary to protect the wood from the moisture which may be driven by the wind through the joints of the slates or tiles, and this is done by covering the boards with a layer of **bituminous felt** or **waterproof paper.** This lessens both the perviousness and conductivity of the roof.

Brick is a worse conductor than stone. **Stone** walls should therefore be thicker than brick if they are to prove the same protection from extremes of temperature. Doubtless it is for this reason that the Education Department insists on stone walls being 20 inches thick, while solid brick walls need not exceed 13½ inches.

Plaster is a worse conductor of heat than either brick or stone. Not only, therefore, does it render a wall more sightly and amenable to decoration: it also adds to the comfort of the room.

Glass, on the other hand, is a better conductor than plaster and brickwork, and has the further disadvantage of being used in exceedingly thin sheets; it is the cause of more variation in temperature than any other portion of the structure of a house. The thickness of plate-glass is a point in its favour, and double panes are sometimes used, one on each side of the window-sash, in order to lessen the loss of heat through the window.

The superiority of **lead** over copper for roof-coverings, in respect of conductivity, is remarkably striking, but in practice the difference would not be much felt, as both are laid on boards which are themselves satisfactorily bad conductors.

The colour of materials has some effect on their absorption and radiation of heat. White and black are the two extremes, and between them, in order of absorption, are pale-yellow, dark-yellow, light-green, Turkey-red, dark-green, and light-blue. The glittering whiteness of the buildings on the shores of the Mediterranean and in other hot countries helps to keep them cool in the flaming sunshine, while in manufacturing districts in England the dark-slated roofs of many of the mills and weaving sheds are covered in early summer with whitewash to reduce the heat of the rooms beneath,—practical applications of this law of colour.

In any house the least **variation of temperature** is found in the basement rooms or cellars, the greatest in the attics. The variation is especially noticeable in attics where the slates or tiles are laid on laths without felt or boards, and where the ceiling is not plastered. Because cellars are of equable temperature, it must not be concluded that they are the most healthy of habitations. On the contrary, they are usually very much the reverse: they are generally damp, the temperature although equable is low, and they are insufficiently lighted and ventilated. The healthfulness of a house does not inhere in temperature alone, but in many other qualities of varying importance.

Warming and **ventilation** are, of course, the most important means of regulating the temperature of a house, and in the ideal arrangement the inlet and outlet of air would be under perfect control, so that the temperature of the house could be nicely maintained in spite of external fluctuations. But the cost and difficulty of warming and ventilating a building will be minimized if its construction has been considered with reference to the laws of heat.

The motion of the air is an important factor in the effect which temperature has on the body. A still, cold atmosphere is not as trying to the constitution as air in motion, even though the latter be somewhat warmer. Cold damp winds are more chilling than keen frosty calm. And in a house the motion of the air must be considered in connection with its temperature. Draughts are deadly, or at the least provocative of more or less dangerous and uncomfortable colds. The prevention of draughts is a difficult problem. There is no royal road to it. Much depends on the general arrangement of the rooms and passages, and on the relative position of fireplaces, doors, and windows; much also on the actual construction of the building so that the external walls, roofs, and windows do not absorb and radiate too much heat from the rooms. But the most important factors in the prevention of draughts are proper warming and ventilation. The draughty room is that where the fire must draw its supply of air from door and windows and gaping floor-boards; two or three inlet-ventilators in suitable positions would lessen the draughts, and at the same time make the fire burn better. Indeed, the air may be brought direct to a chamber behind the fire, and warmed there before being allowed to enter the room. Who does not know a room where the fire will not burn properly unless the door is left ajar? Unwarmed halls and staircases are prolific sources of draughts; it is false economy to leave these spaces without any arrangement for heating them.

3. *CLEANLINESS.*

Cleanliness, we are told, is akin to godliness, and dirt may be called a child of the evil one. The dust and smoke of our towns are responsible for more deaths than war. It is well known that dusty occupations are dangerous, the danger increasing with the hardness and sharpness of the dust. All dust is more or less injurious to the respiratory organs. Many "colds" are caused by breathing dust-laden air, and hay-fever is probably due to the inhalation of pollen grains.

But **household dirt** is complex. It includes *inorganic* matter of various kinds, such as fine particles of sand, clay, metals, and (more important than these) defiling soot; and also *organic* matter, the products of putrefaction and decay or emissions from living plants and animals, and comprising myriads of organisms, some of which may produce specific diseases in the persons breathing them or swallowing them with their food.

Of all the forms of household dirt, none is probably more detested by the good housewife than soot. The dry dust blown from a country road is what a child calls "clean dirt"; it is easily swept or brushed away. But the smoky air of towns defiles wherever it floats. No wonder that mistress and maids fast-bind windows and doors to exclude it, preferring close and stuffy rooms rather than admit the outer air with its concomitant filth. The purification of the air is a necessary feature in all schemes of house-ventilation in towns.

But since dirt is so prevalent, it behoves the architect to avoid as far as possible **all ledges, nooks, and crevices, and all unseen spaces** which could give it lodgment. Considered in the light of cleanliness, the ordinary floor, with its plastered ceiling below and gaping boards above, is radically wrong; so also is the confined space so often provided between the ground-layer and ground-floor; so also are lath-and-plaster partitions, hollow walls, and indeed all details of building-construction which provide spaces invisible and inaccessible to the householder. Sooner or later dirt finds its way to these dark places, and vermin breed and wander there, safe from the housemaid's broom and the cat's eager paw.

Floor-boards and blocks, skirtings, and other wood should be thoroughly seasoned, otherwise they will shrink and the joints be filled with dirt. Indeed, for many purposes wood is now frequently superseded by plaster of Paris or cement, and with manifest advantage, as in the case of skirtings and architraves. Plaster cornices with deep hollows and ledges and "bold" enrichments are an abomination. As far as cleanliness is concerned, gas-fires and gas-stoves are better than coal-fires, and the electric light is the best of all illuminants.

Compromise must, of course, enter into the construction of a house as into its plan and design. Cleanliness must be considered in relation to temperature and dryness and the other qualities desirable in dwelling-houses, but it is abundantly clear that sufficient thought has not hitherto been bestowed by house-builders on this important point.

The ideal house in respect of cleanliness is that into which air cannot enter till it has been freed from all impurities; which is built of such materials and furnished in such a manner that the production and retention of dust and dirt within it are reduced to the smallest limits; which burns its own smoke, and carries off all products of combustion, trituration, and decay as rapidly as they are produced; which is constructed so that there are no dark corners, no ledges, angles, and crevices in which dirt can linger; and, finally, which has an abundant supply of pure water, and lends itself to easy and rapid cleansing. Especially in bath-rooms, water-closets, sculleries, kitchens, and other rooms in which much water is used and more or less dirty work performed, the materials should be smooth and impervious; wood and common plaster should give place to concrete, glazed bricks or tiles, and cement. Even the joints of glazed brickwork are now often covered with impervious enamel paint.

In the construction of **hospitals** particular care is exercised in order that dust and germs may have no lodgment; the angles of floors,[1] walls, and ceilings are rounded; the moulds of windows, doors, and skirtings are designed without deep hollows; the materials used in construction are as hard and impervious as possible; and there is light everywhere. The principles which govern hospital construction should be applied to the construction of houses, for sooner or later every house is a hospital on a small scale, and the life or death of the stricken occupant may depend on its sanitary condition.

4. *LIGHT.*

"'**Let there be light**' is said to have been the first command, and truly no command should ever stand before it or bar its way. Pure light purifies, destroys the organic poisons of spreading diseases, makes a cheerful countenance, gladdens the heart, causes the blood to flow quickly, brightly, and of natural hue. Plants, the universal purifiers for man, which take up his breath, which live on his breath, and which give it him back again in food-produce, sicken and die if they have no light, but live and grow, and grow rich in the waves of this their natural inheritance. 'More light! more light!'

[1] See Plate II., and Fig. 27, p. 81.

exclaimed the dying German poet Goethe. 'More light! more light!' exclaims the sanitarian, as he looks on the masses that are dying prematurely in large dense populations, and, touched by Him 'who is clothed with light as a garment', sighs with them over their sorrows, sufferings, and oppressions."

The eloquence of these words of the late Sir Benjamin W. Richardson should not blind us to their truth. His description of the beneficial effects of pure light should be read as the message of science, and all engaged in building should ponder it carefully. The days of window-taxes are gone for ever, but some architects and builders seem to dread their reimposition if one may judge by the sparseness of the windows in their buildings. Only those who have been compelled to pass a considerable part of their days in twilight rooms can appreciate the blessings of ample light and sunshine, or forcibly enough anathematize those who, carelessly or to suit a passing craze, design windows rather for external show than for internal brightness and comfort.

To pass from the glare of summer sunshine into the cool dimness of a long low room lit by a range of low narrow windows, all **mullions and lead-lights,** is a pleasant change, but the same room, in the days of cloud and rain, when books and embroidery are in our hands to while away the time, is a cheerless place till the lamps are lit. Doubtless, a range of low-mullioned windows is pretty, and in the country, where the daylight is not obstructed, rooms may be pleasantly illuminated thereby, but to employ such windows in towns, where the air is often choked with smoke and fog, is a sacrifice of internal comfort to external effect, of the householder's health and eyesight to the architect's fancy.

Carelessness and fashion, however, are not always responsible for insufficient illumination. The architect may honestly attempt to light a room properly and yet fail; perhaps trees intercept the light, or lofty buildings.

Several **formulas** for proportioning the area of windows to the size of rooms have been devised, but the difficulty of the problem is manifested by the dissimilarity of the rules.

Here are a few of them;—[1]

1. Area of window $=\sqrt{B \times L \times H}$. (Morris.)
2. " " $=\frac{B+L}{8} \times \frac{B+L}{4}$. (Chambers.)
3. " " $=\frac{B \times L \times H}{100}$. (Gwilt.)
4. " light-aperture $=\frac{B \times L}{10}$. (London Building Act, 1894.)

[1] These rules have been reduced to the same terms for purposes of comparison:—B = breadth of room, L = length of room, and H = height of room. For a room measuring 15 ft. × 20 ft. × 12 ft. the rules give the following various estimates of window-space:—1. 60 sq. ft.; 2. 38 sq. ft.; 3. 36 sq. ft.; 4. 30 sq. ft.

Some of the difference shown by these rules is due to a difference in measuring the windows; the three first are intended to give the area of the opening in the wall, while the last is the exposed surface of the glass, in other words, the net light-aperture. This golden rule may, however, always be observed, "Try to err on the side of light"; the glare of excessive light may be subdued by curtains and blinds, by tinted glass, by plants and screens, by low-toned decoration, but darkness can only be expelled by the main force of mason and bricklayer.

The desire for light, however, must not lead us to forget that there is such a sensation as **cold.** The more window-space there is in a room—other things being equal—the colder will it be in winter, and also the hotter in summer. Increase of window-space must be compensated in various ways if the comfort and healthiness of the room are to be maintained; double windows may be provided, or (better) double panes of glass separated by a small air-space; or (best of all) radiators, connected with some system of heating-apparatus, may be placed in the window-recesses.

Shortsightedness is often increased, if not altogether caused, by the insufficient or improper lighting of **schoolrooms** and **workrooms.** The importance of window-design is recognized by the Education Department. The principal windows of schools should be to the left of the scholars, but other windows are desired for diffusion of light and for through ventilation, and no room will be allowed in which one at least of the windows does not extend to the ceiling. In the design of **hospitals,** again, lighting is carefully studied, and the extension of the windows quite up to the ceiling is a cardinal point. Every house is at times school and workroom and hospital, and this fact should be borne in mind when the windows of the house are being designed.

5. *AIRINESS.*

To talk of a house being airy almost sends a shiver through some people, **airiness** being supposed to be synonymous with coldness and draughtiness. This is certainly not the meaning of the word which it is here intended to convey. By airiness is meant that condition of the house and its surroundings which ensures an adequate supply of fresh air to every corner both within and without the house. In other words, airiness is the converse of closeness and stuffiness. The rate of circulation within the house should be so gentle as to be imperceptible; outside it is best, except in the bleakest of situations, that the winds should have free play.

In the country **external airiness** can usually be attained, but architects sometimes go out of their way to prevent it by building deep and narrow recesses, or by arranging the house around a central quadrangle or court. In towns the problem is more difficult, and stringent regulations are necessary in order to prevent the repetition of those stifling courts and alleys which are the disgrace of most of our large towns. The death-rate in the slums of a town is often more than double that in the more favoured suburbs.

Loftiness of rooms is an important factor in promoting **internal airiness.** In this respect continental buildings compare favourably with ours. In this country the minimum height of living-rooms and bedrooms as prescribed by building-regulations is usually 8 feet 6 inches or 9 feet, a height which in small rooms gives an utterly inadequate air-space for the occupants and renders ventilation extremely difficult.

In promoting the airiness of the house, ventilation of course plays an important part, and this will be discussed in a subsequent section, but much can be done by a proper disposition of rooms and passages, and a thoughtful arrangement of windows and door-fanlights made to open, especially those in halls, landings, and passages; the windows should extend as near to the ceiling as possible. Just as there should not be any corner where light does not shine, so there ought not to be any place where fresh air cannot circulate; stagnation means impurity.

6. *FIRE-RESISTANCE.*

In towns certain precautions against **conflagrations** are now invariably taken, but in the country, where the chances of extinguishing a fire are much less than in towns, little or nothing is attempted. The upper walls of the country house may be constructed largely of wood, while the same material is used for roofs, floors, windows, doors, skirtings and dadoes, mantel-pieces, partitions, and stairs. From basement to ridge fuel is provided for the flames. Never a winter passes but we read of the destruction by fire of part at least of some historic mansion with treasures of art which cannot be replaced.

The subject of **fire-resisting construction** is both important and extensive, and only the fringe of it can here be touched. It is a question of materials, and also of their arrangement; for instance, an ordinary floor of wood joists and boards is a most dangerous piece of construction, while a *solid* wood floor of the same thickness possesses fire-resisting properties of great value.

Materials may be classed as *combustible* and *incombustible.* Wood is by far the most important combustible material used in a building, and the less that is used the less will the spread of fire be facilitated. The ordinary studded partitions should give place to walls of brick, or to special fire-resisting partitions. Floors may be of steel and concrete, protected beneath by fire-clay[1] or brick. Skirtings and architraves may be of cement. Metal lathing may be used instead of wood laths. Stairs may be of stone or concrete, and in other directions also wood may be superseded by an incombustible material.

The various kinds of wood differ largely, however, in their combustibility. The pines are the most dangerous, and the hard woods the least. A case is on record where an oak post was charred only to a depth of an inch, while a granite column close to it was burnt to powder.

If the combustible materials used in the construction of our buildings are reduced to a minimum, much will have been effected, but care must be taken that the incombustible materials which take their place are at least moderately fire-resisting. The instance just recorded shows clearly that all incombustible materials are not fire-*proof*. Granite crumbles away under great heat, limestones are nearly as bad, and even the best sandstones are poor in comparison with bricks and terra-cotta. Some concrete, again, is extremely brittle when raised to a high temperature, while unprotected iron and steel twist and bend. The ordinary lead or composition gas-pipes are a source of danger in fires, as they melt at a comparatively low temperature, and so let loose the inflammable gas upon the burning structure.

Nearly all household fires are caused by the faulty construction of the **fireplace** or its accessories. I know one room where two fires originated by burning ashes dropping through the joint between the front and back hearths upon the boarded ceiling immediately below; there was no trimmer arch under the hearth or any other protection. Sometimes floor-joists and the purlins of roofs pass directly into chimney-flues instead of being trimmed or supported on corbels. The great heat attained in many slow-combustion grates is another source of danger, and before one of these is fixed in an old house the hearth should always be raised, and the construction of the floor and of the hearth-supports be carefully examined. The proper construction of fireplaces and hearths will be more fully discussed in Chapter VI. of this Section.

To prevent the spread of fire from house to house in towns many somewhat stringent regulations are often enforced. The thickness of the **party-walls** is specified, and every party-wall must be carried through the roof[1] to a height of not less than 15 inches (measured at right angles to the slope of the roof),

[1] See Plate II.

the thickness of the wall to be not less than $8\frac{1}{2}$ inches. In London it is further enacted that "*every party-wall shall be carried up of the thickness aforesaid above any turret, dormer, lantern-light, or other erection of combustible materials fixed upon the roof or flat of any building within four feet from such party-wall, and shall extend at the least twelve inches higher and wider than such erection, and every party-wall shall be carried up above any part of any roof opposite thereto, and within four feet therefrom*".

A fire-resisting **roof** is undoubtedly a great barrier to the progress of a fire, and in towns the flat roof of steel, fire-clay or brick, and concrete, covered with asphalt, is now frequently adopted.

Occasionally—especially in the country—fires are caused by **lightning**, and every house in a solitary and exposed situation should be provided with one or more suitable lightning-conductors.

Into the details of **fire-extinguishing apparatus** it is not proposed to enter, but attention may be drawn to the necessity of providing for large mansions a sufficient store of water for this purpose, with the necessary pipes and hydrants. In smaller houses portable extinguishing apparatus, sometimes known as "chemical fire-engines", will probably suffice; the small hand-grenades may also prove of great service.

CHAPTER II.

GROUND-WORKS.

The nature of building-sites from a medical point of view will be considered in a subsequent section. The architect's point of view may now be taken, and the first observation which the architect makes is that he is, unfortunately, very seldom consulted as to the site of a building; usually his employer comes to him and says: "Build me a house on this ground I have bought", and the architect must do what he can to make a habitable home, though the site be a bed of stiff clay or a swamp.

The **mould or "humus"** which usually forms the superficial layer of the soil, swarms with **living organisms.** Many of these are quite harmless to man,—indeed are Nature's scavengers, beneficial to man by reducing noxious organic matters to innocent inorganic pabulum for plants. Others, however, are pathogenic, and may cause disease in man, some when inhaled, some when received into the alimentary canal, and others only by actual inoculation. Miers and

Crosskey enumerate four conditions as necessary for their life and growth—*food* (organic carbon and nitrogen), *moisture*, *favourable temperature*, and *absence of inimical compounds*. The architect can only concern himself with the first two conditions, food and moisture. These he may remove from a building-site, the former by excavation and the latter by subsoil-drainage; he must also, by means of impervious ground-layers and perfect walls and drains, prevent their subsequent access.

The subject of ground-works will be treated under the following six heads:— 1. Excavation and filling; 2. Subsoil-drainage; 3. Foundations; 4. Ground-layers; 5. Basement walls; and 6. Damp-courses.

1. *EXCAVATION AND FILLING.*

The practical details of excavation need not be discussed. Suffice it to say that all **humus and vegetation** ought to be removed from building-sites. This is an easy matter in many districts, where the surface-soil is only a few inches deep. In others it is not so easy, and in towns especially, where the level of the streets and buildings has been rising for centuries with accumulations of organic and other refuse, it may be a costly operation. Certainly there is not that imperative necessity to remove all humus or even "made" ground, if it is intended to cover the site with an absolutely impervious ground-layer, but the ground-layer *must be impervious*. But under any circumstances, soil which has been contaminated by excreta, or by leakage from drains and sewers, must be removed, and, if necessary, clean material deposited in its place.

A by-law of the London County Council, adopted in 1891, thus deals with **"made" ground**:—"*No house, building, or other erection shall be erected upon any site or portion of any site which shall have been filled up or covered with any material impregnated or mixed with any fæcal, animal, or vegetable matter, or which shall have been filled up or covered with dust, or slop, or other refuse, or in or upon which any such matter shall have been deposited, unless and until such matter or refuse shall have been properly removed, by excavation or otherwise, from such site. Any holes caused by such excavation must, if not used for a basement or cellar, be filled in with hard brick or dry rubbish, or concrete or other material to be approved by the District Surveyor.*"

Frequently the lowest floor of a building is above the natural surface of the ground, and **filling** has to be adopted. Any clean gravel, sand, brick-rubbish, or loam will be satisfactory. Ashes are sometimes used—usually boiler-ashes, but objection is often taken to them because they harbour vermin. Coarse concrete, however, does the same. Ordinary house-refuse and road-sweepings, which contain all manner of garbage, must not be used. Whatever kind of filling is adopted, it should be well consolidated, either by ramming, or, in the case of sand, by wetting.

2. *SUBSOIL-DRAINAGE.*

The greatest difficulty with which an architect has to contend in the ground-works of a building is that of the **ground-water** in low-lying lands. Springs on hillsides are easily dealt with, but the water which percolates through mud and gravel only a few feet below the surface of the ground, and rises and falls perhaps with the rise and fall of a neighbouring river or ditch, furnishes a more difficult problem. Nor is a site like this confined to plains; it may be found on the banks of most rivers, even in deep and narrow valleys.

A permanently high level of ground-water is dangerous to health, but fluctuating ground-water is much worse. It is one advantage of subsoil-drainage that it tends to prevent extreme rise of the water, and so lessen the degree of fluctuation.

The level of ground-water, it may be added, is always raised by capillarity. The amount of rise has been estimated at about 1 foot in sands, and 4 or 5 feet in clay and compact marl. The rise will be lessened in many soils by properly opening and draining them.

In many cases, it is a mere farce to talk of **draining the subsoil** to a depth of 6, 8, 10, or 12 feet; not until the ocean has been drained, can the level of the ground-water in many parts of these islands be permanently lowered. Where the sea has to be kept out by dikes and sluice-gates, it is of little use talking about subsoil-drainage. So difficult is it to render dwellings on such low-lying sites habitable, that by the London Building Act, 1894, the London County Council received power to prevent the erection of dwelling-houses upon them. In many elevated places, however, there are damp, even boggy, patches of ground, and these can easily be drained, because there is an outfall for the drain into the valleys below.

Not all ground requires underdrains: many rocky, sandy, and gravelly sites are sufficiently dry already. But every site must be judged by itself, as the nature of the ground varies greatly even in a short distance. It is better, however, to drain too much than too little. The drainage of **clay soils** renders them drier, and, by reducing the evaporation, warmer. **Sandy and gravelly soils** are naturally drier and warmer than clay; on account of their porosity water rapidly sinks through them, and they contain a considerable volume of air. In these the fluctuation of ground-water and consequent exhalation of more or less impure ground-air are more to be feared than dampness.

Subsoil-drains are sometimes—especially where stone is plentiful—merely trenches cut to the necessary depth, and filled to the height of 2 or 3 feet with pieces of broken stone. The ground-water, taking the line of least resistance, finds its way along these "rubble drains" (for so they are called) to the appointed outlet. Sometimes a small square drain is formed at the bottom of the trench with stones, or with tile bottom and brick sides and top.

It is always better, however, to provide pipes for subsoil-drainage, as these permit the water to flow off more rapidly and are less liable to choke than the simple stone drains. They may be either round or D-shaped, and should not be less than 3 inches in diameter. The ordinary unsocketed agricultural drain-pipes are frequently used, but there is some difficulty in keeping the ends of the pipes together, both horizontally and vertically. To obviate this, half collars 3 or 4 inches long are sometimes placed under the joints, or pipes with a socket on the lower half only are used. Frequently ordinary socketed drain-pipes are used, but with the joints left without cement or clay. The two last methods are the best. Sometimes, as in Brooke's patent, a D-shaped subsoil-drain is laid flat-side down, and upon it the sewage-drain is supported by means of concave pipe-rests made to fit the curves of the two drains.

Whatever kind of pipe is used, the trench above should be filled with broken stone or screened gravel to the height of 2 or 3 feet.

In very wet and **loose sandy soils**, drains may carry away, little by little, considerable volumes of sand, and so endanger the ground and structures above. At Worksop, the earthenware sewers have caused so much mischief in this way that large portions of them have had to be replaced with iron. In extreme cases of this kind, subsoil-drains will be best omitted, and the money thus saved expended on a good layer of asphalt with concrete bed over the whole site.

The depth of subsoil-drains should be as great as possible—the deeper the better,—but considerations of outfall and expense will frequently prevent the depth being more than 3 or 4 feet below the basement floor. Where the drains are shallow, they should be closer together than is necessary when they are deep.

The distance apart of subsoil-drains must depend upon their depth, the quantity of water, and the nature of the ground. The stiffer the ground, the closer must they be. In stiff clay they should be laid every 3 or 4 yards, in loamy clay every 5 or 6 yards, while in sand and gravel they may be 10 or 15 yards apart. Indeed, in the latter case, it is frequently sufficient to carry a drain around the outside of a building, as shown in fig. 19. In the other cases, however, it will usually be necessary to lay branch drains across the site in addition to the important drain encircling it.

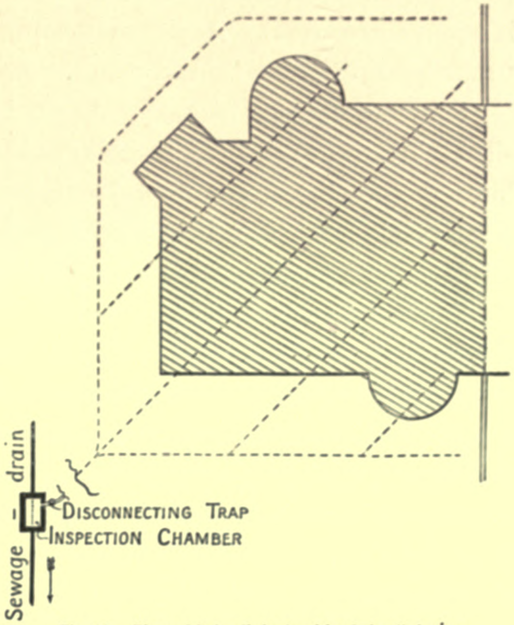


Fig. 19.—Plan of Subsoil-drains (the Subsoil-drains shown by dotted lines).

The outlet for ground-water must be arranged according to circumstances. In many towns now, especially where the sewage is treated chemically, there is a great objection to the ground-water being conveyed to the sewers, and special "sewers" for surface-water and ground-water are provided, emptying into the nearest stream at various convenient points. In the country the subsoil-drains may be carried to the nearest stream, or, if there is sufficient fall, brought to the surface of the ground at some distance from the house and used for irrigation. Where, however, they must be connected with the sewage-conduits, they must be disconnected, as well from the house-drain as from the public sewer. This may be done by means of a disconnecting trap and air-shaft. A convenient place for the trap is the side of an inspection-chamber, as shown in fig. 20. Instead of the pipe-shaft, a small chamber is sometimes built of bricks with a disconnecting trap between it and the sewer-disconnecting chamber

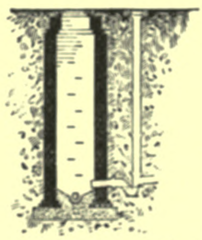


Fig. 20.—Inspection-chamber with Inlet for Subsoil-drain.

3. *FOUNDATIONS.*

It is impossible to lay down general rules for the safe bearing-power of **different kinds of ground.** Each site must be judged by itself, but, speaking roughly, it may be said that alluvial soil, or quicksand, ought not to be loaded with more than about 10 cwts. per sq. ft.; soft clay (near the surface), from 10 to 15; moist clay, from 15 to 30; compact clay, nearly dry, from 30 to 50; dry compact clay of considerable thickness, from 50 to 100; loose sand, from 20 to 30; compact sand, or gravel and sand, from 40 to 60; ditto, dry and prevented from spreading, from 80 to 120, or even 150. The great point to be observed in designing foundations is so to arrange them that the pressure on the ground is equal throughout. Unequal loading (except on the firmest ground) gives rise to unequal settlement and probably cracks.

Foundations can be safely omitted only on exceptionally firm and uniform sites. Almost invariably some kind of foundation is required in order to distribute the weight of the superincumbent building over an area of ground sufficiently large to bear the weight without yielding. Foundations may be of timber, stone, brick, concrete, and even iron and steel.

Timber is seldom used nowadays for the foundations of buildings, except in the form of piles, and then only on soft ground of considerable depth.

Stone foundations are never used far from the quarries where the stone is obtained. In many localities, such as the flag-stone districts of East Lancashire and the West Riding of Yorkshire, they are still largely used, although even there they are being superseded by concrete. They may be obtained of any width up to 5 or 6 feet, and of any thickness up to about a foot. They are usually of strong coarse rag-stone, and not at all uniform in thickness. Sometimes two or more courses are employed, the second course narrower than the first, and breaking joint with it. No mortar is used either on their beds or joints. The chief objection to these footings is their longitudinal incohesiveness. (See fig. 22, p. 79.)

Brick footings are open to the same objection, and to the further one of transverse incohesiveness, especially where common-lime mortar is used in their construction. They consist of several courses of bricks, the lowest course being usually twice the breadth of the wall above, and the total height of the footings being not less than two-thirds of the breadth of the wall. They are narrowed as required by regular offsets (usually quarter-brick), as shown in fig. 21, which illustrates a brick and concrete foundation for an 18-inch wall. Five courses of bricks are here shown, having a total height of about 15 inches; four courses would meet the demands of most by-laws, but in the illustration the lowest projection is strengthened by being formed of two courses, an advantage where concrete is not used.

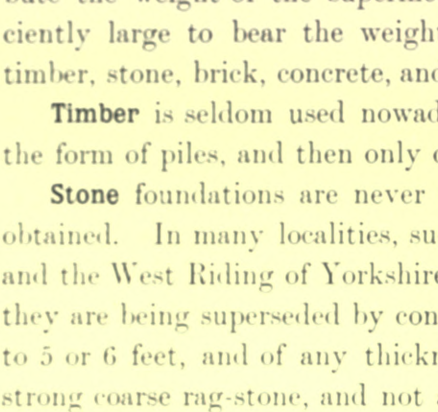


Fig. 21.—Brick and Concrete Foundation for 18-inch Wall.

A, concrete foundation, 4 ft. wide; B, brick footings; C, portion of footings built up to carry wall-plate E; D, stoneware ventilating damp-course 3 inches thick; E, wood wall-plate; F, wood floor-joist; G, floor-boards; H, concrete ground-layer.

On good ground, the brick footings twice the breadth of the wall above will be sufficiently firm, as shown in fig. 25, p. 80. Where the ground is soft—whether natural or "made"—**a bed of concrete** not less than 8 inches wider than the brick footings is usually laid under them; its thickness should be not less than one-fourth its breadth, but will vary according to the nature of the ground, the weight of the building, and the quality of the concrete.

Brick footings as described above are made obligatory by the London Building Act, 1894, in all cases, except by special permission of the Council. Perhaps the by-law is on the whole a wise one, as concrete is so easily scamped, but there are many cases in which concrete alone would be more economical and more stable.

The ideal foundation, where great depth is unnecessary, is a solid bed of good concrete of uniform thickness, spread over the whole of the building-site and extending 2 or 3 feet beyond the walls on all sides. Its thickness must depend upon the nature of the ground and the weight of the building, but can seldom be less than 12 inches. Such a foundation is illustrated in fig. 23, p. 79. The concrete foundation with thinner ground-layer, shown in fig. 18, page 56, is a cheaper modification of this. Over all a layer of asphalt should be spread, forming a damp-course both for floors and walls, and on it the walls may be built, and the basement floors, whether of wood blocks or concrete, may be laid.

Continuous concrete foundations and ground-layers cannot, however, always be adopted, as it is often necessary to carry some portion of the walls to a depth much below that of the basement floor.

The use of **iron and steel** in foundations can only be mentioned. Frequently the metal is in the form of steel rails embedded in concrete. Sometimes, as in the Ransome system, it consists of a series of twisted wires or rods embedded in the lowest part of the concrete to give transverse strength to the foundation. In either case, a stronger foundation can be obtained in less depth than when concrete alone is used.

Concrete for foundations was at one time generally made with a matrix of common lime, but nowadays hydraulic lime or Portland cement is almost invariably used. The latter is by far the stronger material, and good cement is more uniform in quality than good lime; hence the use of Portland cement is rapidly extending. There is, however, a great deal of rubbish sold as Portland cement—coarsely-ground and of a yellowish hue,—and this must be avoided. Plasterers, it may be said, regard it with especial favour; it is cheap, and great strength is not, they think, necessary in their work.

Portland cement should be *finely-ground*, *sound*, and of *sufficient strength*. The *fineness* of good cement is such that not more than 10 per cent will remain on a sieve containing 2500 meshes in a square inch; the best cement will leave a residue of less than 10 per cent on a sieve with 5625 meshes in a square inch. *Soundness* means that the cement does not contain free lime or other ingredient which might cause the softening or cracking of the concrete some time after it had set. To ensure the slaking of the free lime, the cement should be spread in a perfectly dry place for a week or two before it is used, and occasionally turned over. The *strength* of cement is usually tested by its resistance to a pulling stress or tension; briquettes 1 inch or 1½ inch square are made of neat cement, or of cement mixed with 3 parts (by weight) of sand, and kept one day in air, then placed in water. The neat briquettes are usually tested at the end of 7 days, and should give an average tensile strength of 350 or 400 lbs. per sq. inch; and the briquettes of cement and sand should have a strength of about 120 lbs. per sq. inch at 7 days, and 200 lbs. at 28 days.

The bulk of concrete, however, consists of other materials, known as the **aggregate**, which may be gravel, broken stone or brick, coke-breeze, &c., and sand. For foundations the hardest materials should be used, such as gravel and hard broken stone. In London, Thames ballast is largely used, but a better (because cleaner) material is the broken and screened shingle which the Great Eastern Railway Company prepares at Lowestoft. The aggregate should be passed through a screen with 3-inch meshes, and should be free from clay, organic refuse, and other impurities.

Sand is almost invariably used in the making of concrete. A considerable quantity is present in Thames ballast, and no additional quantity is required when this is the aggregate employed. A certain amount of sand is made in breaking stone, quite sufficient, indeed, except when the stone is extremely hard; soft stone often yields too much sand, and some of it must be screened out if strong concrete is required. The volume of sand in concrete for foundations should not exceed one and a half or, at most, two volumes of the cement; if more than this be present in an aggregate, part should be screened out. Undoubtedly the best plan is to screen *all* the sand from the aggregate, then the cement, sand, and aggregate can each be accurately measured; but the builder will have to be closely watched or the plan will not be carried out. All sand used for concrete should be clean, sharp, coarse, angular, and durable; pit-sand is usually much improved by washing. Street-scrapings are not sand in the estimation of an architect or magistrate, whatever they may be in that of a jerry-builder.

The proportions of cement, sand, and aggregate used in concrete for foundations vary from 1 + 1 + 4 to 1 + 2 + 8 or even 10. Good work may be ensured by a mixture of *one* part of cement, *one and a half* parts of sand, and *five* parts of broken stone or gravel. When such a mixture is specified, the builder will frequently argue that it is a 1 to $6\frac{1}{2}$ mixture, and will measure the sand and stone together in a box $6\frac{1}{2}$ times the volume of a bag of cement. This is advantageous to him, for the sand merely occupies the interstices in the broken stone, and his mixture really contains *one* part of cement, *two* or *two and a half* of sand, and *six and a half* of broken stone; or, to put it another way, the builder's concrete will contain one-fourth less cement than concrete made according to the specification. Perhaps for ordinary foundations—especially in small buildings where the constant supervision of a clerk-of-works cannot be afforded—the wisest method is to specify that the gravel or broken stone shall be measured with the sand naturally contained in it or made in breaking it, and that no more sand must be added.

The **ingredients** of concrete should always be **accurately measured**. A full bag of cement weighing 2 cwts. contains about $2\frac{2}{3}$ cub. ft., and boxes for the aggregate are often made some multiple of this: thus, the box to contain five parts of aggregate would contain $13\frac{1}{3}$ cub. ft., and might measure 4′ 7″ × 2′ 6″ × 1′ 4″. It should be ascertained, however, that the bag does contain 2 cwts.; frequently a bag of cement weighs only 200 lbs., and half-bags are common.

The **mixing** of concrete is usually done by labourers on a platform of wood, but for large works a machine is employed. In hand-mixing, the ingredients should be turned over twice dry, sprinkled with *clean fresh water* while being turned over a third time, and finally turned over a fourth time. The mixture should at once be deposited in position, and moderately pounded. Foundations more than about 15 inches thick should be deposited in two or more layers, unless several gangs of men are employed in mixing and depositing the concrete.

4. *GROUND-LAYERS.*

The pores of the ground are filled with water or air. The water may be reduced by drainage, but the ground-air will be increased by it. Sandy soils may contain air to the extent of 40 or even 50 per cent of their volume.

Ground-air is dangerous in more ways than one: it contains a relatively large proportion of carbonic acid, the proportion increasing with the distance from the surface. At Dresden, Flach found the ground-air to contain 3 per cent of the gas at a depth of 2 metres, and no less than 8 per cent at a depth of 6 metres; even 3 per cent is about one hundred times as much as that contained in normal atmospheric air. When we remember that air containing

$2\frac{1}{2}$ per cent will extinguish a candle, the dangerous character of ground-air is easily understood.

A further and greater danger is that ground-air may contain other gases, such as ammonium sulphide and marsh-gas, due to the fermentation and decomposition of organic matters, and, in towns especially, may be charged with sewer-air and with coal-gas from leaking mains. The explosive character of air mixed with coal-gas is not its only danger; it may produce headache, nausea, and more distressing symptoms, while its presence may be unsuspected, as the gas may be deodorized by passing through the soil.

And finally, ground-air may contain the spores of pathogenic bacteria which have found a suitable nidus in the soil.

The movement of ground-air is a well-ascertained fact, and is influenced by wind and rain, by the rise and fall of ground-water, and by changes of temperature and barometric pressure.

A warm house tends to draw the cool damp ground-air into it, especially when the external temperature is low. The explosions of coal-gas in houses which have no connections with the gas-mains are evidence in proof. Hence the necessity of **covering the site of a house** with a layer which shall be impervious alike to moisture and to gases, even under pressure.

"*The site of every house or building shall be covered with a layer of good concrete, at least six inches thick, and smoothed on the upper surface.*" Such is the by-law in force in London. In many towns a layer of asphalt may be used instead of concrete. If good results are desired, both concrete and asphalt should be used, as concrete alone is not impervious, and asphalt is all the better for a firm and level bed. Examples of ground-layers are given in figs. 18, 21, 23, 25, 28, and also in Plates II. and III.

Concrete for ground-layers need not be as strong as that for foundations, but should be more solid; it must therefore contain more sand in proportion to the gravel or other broken material. Coke-breeze is not a good material for the aggregate; harder and more impervious material is better, such as gravel, broken stone, slag, hard brick, even broken flints. The aggregate, too, should be of smaller size; all should pass a screen with $1\frac{1}{4}$-inch or $1\frac{1}{2}$-inch square meshes. The sand may be finer than that used for foundations. The proportions may be 1 cement + 2 sand + 4 aggregate, or 1 cement + $2\frac{1}{2}$ sand + 5 aggregate. The wet concrete should be well pounded, either with a light rammer or the back of a spade, and trowelled to a smooth surface. The last operation reduces considerably the perviousness of the concrete, and a further reduction may be effected by covering the layer with a coat, however thin, of neat cement, or even of lime-whiting.

Professor Tichborne found the **relative porosity** of certain mortars and asphalt to be as follows:—1. Common lime-mortar (1 lime + 2 sand), 100; 2. plaster of Paris, 75; 3. Roman cement, 25; 4. Portland cement, 10; 5. asphalt, 0. The advantage of asphalt ground-layers is evident from these figures. Portland cement, indeed, approaches asphalt, but Portland cement, it must be remembered, is not concrete: admixture with sand and other material increases its permeability, however carefully the admixture may be made.

Asphalt is a generic name, comprising many varieties of material, good, bad, and indifferent. It may mean the natural bituminous limestone found at Pyrimont Seyssel, Limmer and Vorwohle, Val de Travers, and other places, or more commonly, a compound of any one of these with more bitumen and sand. It is also used to designate a number of compounds, of which coal-tar pitch is the chief ingredient, but which may contain oil, sand, quicklime, tar, and other materials. These may be called "artificial asphalts" to distinguish them from the "natural asphalts".

Natural asphalts are undoubtedly more durable and trustworthy than the others, but they are also more expensive. The artificial "British" asphalt can be laid at one-half the cost of natural asphalt. For good work, however, one of the natural asphalts should be used. The preparation and laying of the material require considerable care, and ought always to be done by skilled men. An iron caldron is heated and gradually filled with small pieces of "mastic" asphalt, and a small proportion of natural bitumen to act as a flux, the mixture being stirred at intervals. In three or four hours from lighting the fire the mixture will be ready for use. Great care must be taken that the concrete bed is thoroughly dry, as otherwise the moisture will form steam and burst through the asphalt. To ensure the dryness of the bed, it should be allowed to stand for two or three weeks (more if possible), and hot cinders should be spread on it before the asphalt is laid. After the removal of the cinders, the caldron man takes a quantity of the viscous asphalt from the caldron, in a pail or ladle, and empties it on the bed; here the spreader at once commences to work it with a wooden rubber, carefully compressing it to the specified thickness, which need not be more, for ordinary work, than half an inch. Wood laths of the same thickness as the proposed coat of asphalt, are placed on the concrete to serve as guides in spreading the layer. Particular care must be observed that the junction between each new spreading and the work already executed is carefully made. In very wet situations, two $\frac{3}{8}$-inch or $\frac{1}{2}$-inch layers must be used instead of the single layer, if perfect watertightness be desired.

The great objection to **artificial asphalts** is that they become very soft in hot weather, and are therefore apt to "run", and even to allow pieces of grit or sand to sink through them. They may, however, be used with advantage in buildings for which the natural asphalts are too costly. An artificial asphalt is better than no asphalt at all. They are chiefly mixtures of pitch and creosote oil, boiled in a caldron, a variable quantity of fine hot dry sand being subsequently added. Too much oil renders the asphalt soft and liable to run in hot weather, while excess of sand renders it brittle—especially in cold weather,—and may lead to cracks or even general perviousness. The mixtures are usually laid in a more liquid state than the natural asphalts. The so-called "British" asphalt is a well-known variety. Briggs's "Tenax" and White's "Hygeian Rock" building-compositions are better materials of similar nature, but supplied in powder ready for the caldron.

The various kinds of **floor-surfaces** suitable for basements will be described hereafter.

5. *BASEMENT WALLS.*

Damp and ground-air may not only rise through the floor of a house; they may find entrance through the **basement walls.** It is of little use covering the site with an impervious layer of asphalt if the walls be left pervious and in contact with the ground. Hence the necessity either of surrounding the basement with an open area, or of building the walls of such materials and in such a manner as to prevent the ingress of moisture and air.

Many an old house nestling into a hillside has nothing to protect its back wall from damp but a trench full of rubble stones with a stone drain at the bottom. For a time such a **rubble-trench** may be of service, but it is sure to choke at last, and then it ceases to be any protection.

Undoubtedly **an open area,** sufficiently wide to admit of easy cleansing, and extending to a depth of about 6 inches below the damp-course under the basement floor, is an effectual preventative of ground-air and ground-damp in walls. The bottom of the area should be formed of concrete, with asphalt similar to that on the ground-layer and walls; if good natural asphalt with a gritted surface is used, no further covering is required. This arrangement is illustrated in fig. 18, page 56. In very wet ground it will be advantageous to continue the asphalt layer through the area wall and up the back of it as shown in the figure; the house will then stand in a dry waterproof dam.

Where space for an open area cannot be afforded, a **dry area,** or **"air-drain"** (as it is sometimes termed), may be formed with sloping flags, or with an additional wall of brick or stone. Fig. 22 illustrates a bad example of a basement surrounded by a dry area formed with flags; the window-sill and the sloping ground conduct the rain-water to the upper edge of the flagging and so into the wall and area; there is no damp-

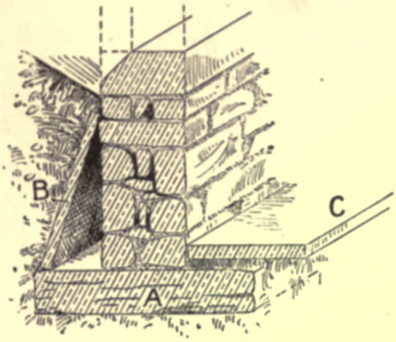


Fig. 22.—Bad Example of Stone Wall and Dry Area.

A, stone foundation; B, flags forming area; C, flags forming floor.

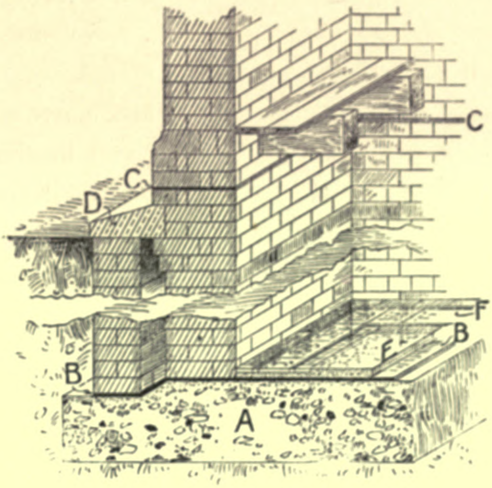


Fig. 23.—Dry Area formed with Brickwork.

A, concrete foundation and ground-layer; B, lower asphalt damp-course; C, upper asphalt damp-course; D, stone coping over area; E, concrete floor-surface; F, tile border on cement mortar.

course to the wall, and the floor is formed of flags without any underlying bed of concrete or layer of asphalt.

Of course a dry area may be constructed of stone without the defects depicted in the last figure, but it is a better plan to form the area by means of an additional thin wall of brick or stone, the wall and area being covered at the surface of the ground with weathered stone, concrete, or bricks, which must be jointed and pointed with cement-mortar so as to prevent the ingress of surface-water. Examples of dry areas formed with an additional brick wall are shown in figs. 23 and 24. The wider the area is made the better; two horizontal damp-courses should be laid in the wall, as at B and C. Small openings for ventilating the area should be provided at intervals, as shown at E E in fig. 24.

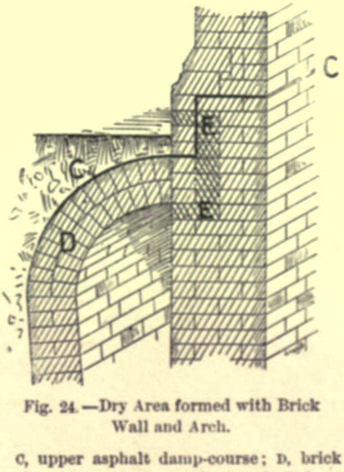


Fig. 24.—Dry Area formed with Brick Wall and Arch.

C, upper asphalt damp-course; D, brick arch over area; E E, ventilating-shaft from area.

Closely akin to a dry area is a **hollow wall.** In this the air-space or cavity is formed within the main wall itself and not outside it as in the previous case. The arrangement is illustrated in fig. 25, but it cannot be recommended, as part of the wall is left unprotected, and in very wet ground the water will penetrate to the cavity and soak into the inner lining of brickwork.

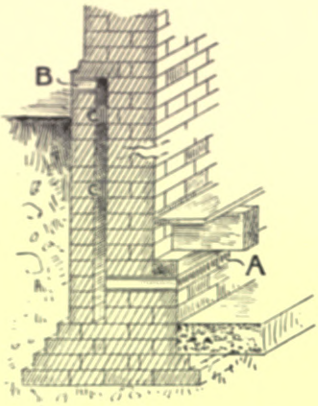


Fig. 25.—Hollow Basement Wall.
A, lower stoneware ventilating damp-course; B, upper stoneware ventilating damp-course; C C, bonding-blocks.

Neither the hollow wall nor the dry area is a satisfactory method of construction. In each there is a narrow cavity, well-nigh impossible of access to the householder, but capable of harbouring vermin and facilitating their movements, and while both are of some use in retarding the ingress of ordinary damp, they assist rather than impede the entrance of ground-air and water. Where an open area of sufficient width cannot be formed, the most sanitary construction is a **solid wall,** rendered impervious alike to moisture and to air.

As most bricks and stones are very far from being impervious, it follows that a wall built of these materials alone—however well it may be constructed—cannot be absolutely waterproof. Certainly a wall built of good bricks in **Portland-cement mortar** (*one* part of cement to *two* of sand) and well grouted with neat cement, *ought* to be practically impervious, especially if a cavity (which need not be more than $\frac{1}{2}$ inch or $\frac{3}{4}$ inch wide) be left in the body of the wall and run with grout; but such is the carelessness of the ordinary bricklayer that it is almost certain it will not be. A coat of Portland-cement mortar (1 cement + 1 sand) carefully applied to the exterior of the wall after the joints have been well raked out, is a safer protection than the grouted cavity.

A method sometimes adopted is to build a vertical layer of **roofing-slates** between two skins of brickwork, but the process is tedious and expensive.

A better method is to form a **narrow cavity,** $\frac{1}{2}$ inch or $\frac{3}{4}$ inch wide, in the body of the wall, and run it full every two or three courses, with molten **asphalt or waterproof composition.** Great care must be taken that the cavity is kept free from mortar, &c.; this can best be done by means of a thin board built into the wall to form the cavity and lifted out every two or three courses, when the cavity can be at once filled with asphalt. In building walls of this kind, it is better that the mortar in the brickwork should not extend quite up to the cavity, in order that the composition can key into the joints, as shown in fig. 26. For convenience in filling the cavity, one skin of the brickwork is often carried

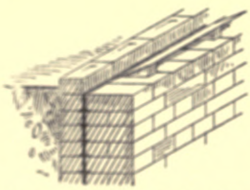


Fig. 26.—Wall with Cavity filled with Artificial Asphalt.

one course higher than the other, and a piece of sheet-iron resting on wedge-shaped chairs is placed on the lower brickwork as shown in the figure. Or a spouted utensil may be used for pouring the liquid. The cavity must be quite free from water when the molten composition is run in.

For waterproofing walls in this way, some kind of artificial asphalt is usually employed. The mixture of pitch, oil, sand, &c., made by rule of thumb by the builder or one of his labourers, is far from reliable, unless very careful supervision be exercised. More satisfaction will be given by the use of one of the well-known compositions specially made for the purpose, such as the "Hygeian Rock" and "Tenax" compositions, and "Sub-aqueous Asphalt". Sometimes one of the natural asphalts,—Limmer, Seyssel, &c.,—is used.

One disadvantage of this method of construction is that the outer portion of the wall is not protected against the damp. In order that this portion may be as small as possible, the outer skin of the wall should be only a half-brick thick. A horizontal damp-course, extending over this outer skin, must always be laid a few inches above the surface of the external ground. A second disadvantage is that no inspection of the vertical damp-course is possible, and consequently defects—which may occur through carelessness or the presence of small pieces of mortar or brick, or water—may not be discovered till damp has struck quite through the wall, perhaps some time after the house is occupied.

The only way of making the whole of a wall in wet ground quite dry is to spread a **water-proof coat on the outside of the wall.** For cottages and other buildings where economy is a paramount consideration, a very thin mixture of boiled pitch and oil may be applied to the wall with a brush, but this method has little to recommend it save its cheapness. The best method is to spread on the wall one or two layers of natural asphalt, carefully connected with the horizontal damp-course as shown in fig. 27. In connecting horizontal and vertical damp-courses a triangular fillet is usually employed as at D. The top of the vertical asphalt may be finished by tucking it into a joint above the ground to the depth of about an inch, or may be connected with a second horizontal damp-course at that level. Where the exposure of the vertical coat of asphalt

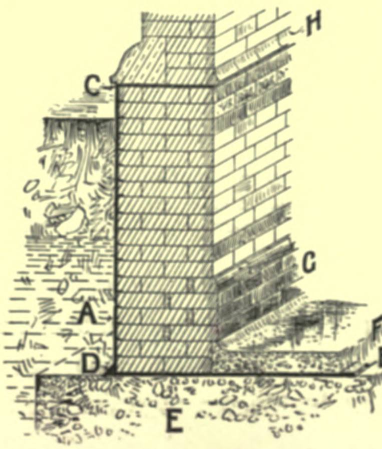


Fig. 27.—External Vertical Damp-course of Natural Asphalt.

A, vertical asphalt damp-course; B, lower horizontal damp-course; C, upper horizontal damp-course; D, asphalt fillet; E, concrete foundation and ground-layer; F, concrete floor finished with terrazzo, and rounded to meet plinth; G, glazed brick plinth; H, glazed brick capping to dado.

above the ground is objectionable, recourse may be had to the arrangement shown in fig. 24, where the asphalt is faced outside with a 4½-inch skin of brickwork.

Before laying a vertical damp-course of natural asphalt, the wall should be dried by means of coke-fires and the joints raked out to the depth of an inch. The joints are then filled with mastic asphalt, and afterwards the proper layer is spread upon the wall. Sometimes a single layer ½-inch thick is used, but in wet situations two ⅜-inch layers are necessary.

It not unfrequently happens that a **basement or cellar** is required to extend below the permanent level of the ground-water, or **below the flood-level** of an adjacent river. It is then necessary to cover the ground-layer and walls with a sheet of asphalt absolutely flawless and continuous, and so arranged as to resist the pressure of the water. Fig. 27 exhibits a simple method of doing this; the horizontal coat is spread either on a level concrete bed or when the walls have been built to the level of the ground-layer, and on it the upper walls are built and a sufficient weight of concrete is deposited over the ground-layer to resist the upward pressure of the water. In exceptional places, where the pressure is great, the concrete ground-layer may be formed with a concave surface (as shown in fig. 28), on which the asphalt is laid. An inverted arch of one or more 4½-inch rings of brickwork in cement-mortar may then be built on the asphalt and finished above with concrete; or the brick arch may be omitted and concrete alone be trusted to resist the upward stress.

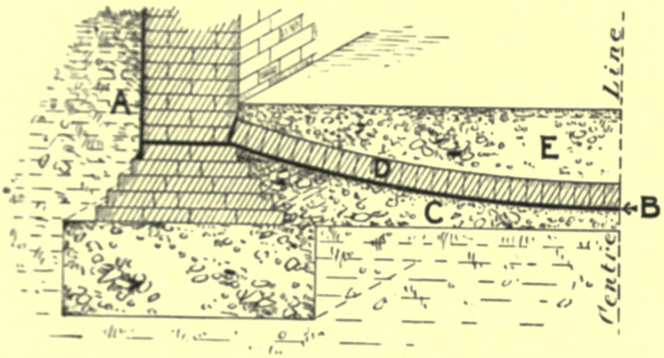


Fig. 28.—Asphalted Floor and Wall to resist considerable Pressure of Water.
A, vertical asphalt damp-course; B, lower horizontal damp-course; C, concrete bed to receive asphalt; D, inverted brick arch; E, concrete filling and floor.

In the case of cellars sunk below the permanent level of ground-water and therefore below the drainage-level, the formation of an open area is obviously unwise, as no outlet can be obtained for the rain-water which may find its way into it. The best mode of construction in such cases is the solid wall asphalted outside, even though it be necessary to construct a temporary coffer-dam in order to keep out the water during the progress of the work. Only in the most exceptional circumstances, however, should cellars be constructed below the level of the ground-water. It is always more conducive to health to raise a house-floor well out of the ground, than to sink it below the ground, and it is usually cheaper.

Where ordinary open areas, dry areas, and cavity-walls are adopted, provision must always be made for **ventilating and draining** them; otherwise they will prove of little or no use.

The **materials** used in the walls of basements, especially in those walls which are in actual contact with the ground, are often of the commonest kind. Anything is good enough to be buried is the builder's thought. Certainly where an external asphalt layer is adopted, there is not so great a necessity for impervious and non-absorbent materials, but as a general rule it may be said that materials exposed to damp, as in basement walls, should be hard, dense, and durable. Soft porous bricks and coarse friable stone are out of place in such situations. The nature and properties of building-materials will be discussed a little more fully in the next chapter; suffice it now to say that the bricks should be hard and dense—blue Staffordshire bricks for the best work,—the stone close-grained, and the mortar of the best. It is a good plan to use hydraulic mortar in all basement walls, either Lias lime, or (better) Portland cement. Concrete composed of Portland cement, sand, and hard, well-broken aggregate, mixed in proper proportions ($1 + 2 + 3$ or 4), is an excellent material.

6. *DAMP-COURSES.*

The word "**damp-course**" is usually applied to a *horizontal* damp-resisting course forming part of the structure of a wall. The building-regulations of most large towns and cities require such a course to be laid in all walls of buildings. The London County Council's by-laws state that it must be "at a level of not less than six inches below the level of the lowest floor". Opinions may differ as to the necessity of placing the damp-course six inches below the floor-level, where a solid floor is adopted as in figs. 18, 23, and 27, but where an ordinary joisted and boarded wood floor is desired, the depth of six inches will probably be exceeded, as in figs. 21 and 25.

For walls in contact with the ground, however, one damp-course is not sufficient. Reference to fig. 25 will make it clear that the outer skin of the hollow wall there shown will absorb moisture from the ground; and this moisture will rise by capillarity into the solid wall above the cavity and probably make itself visible on the plaster and wall-paper, unless its upward progress is stopped by a damp-course at B. This upper damp-course may be laid over the outer portion only of the wall, but in most cases it is a cheese-paring economy not to cover the inner portion as well. For the necessity of two damp-courses, see also figs. 23 and 24.

Many different kinds of materials and contrivances have been used for damp-courses. Good **asphalt** is one of the best, and has the great advantage of forming a continuous sheet with the asphalt ground-layer. Nothing further need be said about the ordinary methods of using natural and artificial asphalts, as they have already been described at some length with reference to ground-layers and vertical damp-courses, but attention may be drawn to one variety of asphalt damp-course, known as Callender's **Pure Bitumen Damp-course,** which consists of sheets of bitumen supplied in lengths of 24 feet, and in various widths. To lay the damp-course, the sheets are simply unrolled on the wall and the several lengths joined together by means of a hot iron. The material is not a felt, and is guaranteed free from coal-tar and pitch.

Somewhat akin to asphalt is **bituminous felt,** or, as it is sometimes called, **fibrous asphalt,** which can be obtained in sheets of various widths from $4\frac{1}{2}$ inches upwards. The sheets are laid to overlap about 2 inches at the joints, or two thicknesses are used, breaking joint. These sheets are very convenient and economical, especially for works in the country, and have the advantage of not cracking when any settlement of the building takes place. Doubts about the durability of the material are sometimes expressed, but with what reason I cannot say.

A layer of good **Portland-cement mortar** (1 cement + 1 sand) is sometimes used, but cannot be recommended, as it is not entirely impervious at the best, and cracks with any settlement of the building

Two courses of strong **slates,** thoroughly bedded in cement-mortar and laid to break joint, are a better remedy, although they also are liable to fracture, and leave a thick unsightly joint in the face of the stonework or brickwork, unless a bed is sunk to receive them.

Sheet-lead was formerly much used for damp-courses and answered the purpose admirably, but the introduction of other satisfactory but less costly materials has led to its partial abandonment.

Two or three courses of **blue Staffordshire bricks** with the vertical joints left open are economical, and, above ground, effective.

Where the lowest floor of a house is of wood and above the ground or area outside, the best material is the **stoneware ventilating damp-course,** shown in figs. 29 and 30, and also in fig. 21, p. 72. The slabs are perforated, and may be obtained in thicknesses from $1\frac{1}{2}$ to 3 inches, and in widths from $4\frac{1}{2}$ to 18 inches and upwards; the length of the slabs is usually 9 inches. Besides being proof against damp, they afford continuous and constant ventilation to the space below the floor, and so help to prevent the decay of the wood. Special slabs are made for salient angles.

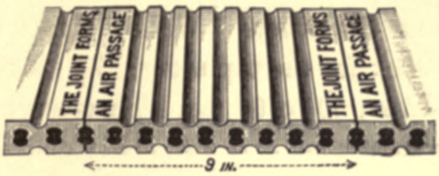


Fig. 29.—"Broomhall" Vitrified Stoneware Ventilating Damp-course, 1½, 2½, and 3 inches thick, with Open Joints.

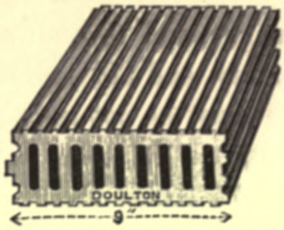


Fig. 30.—Doulton's Vitrified Stoneware Ventilating Damp-course, 1½, 2½, and 3 inches thick, with Tongue-and-groove Joints.

CHAPTER III.

EXTERNAL WALLS.

The walls of houses are designed for a twofold purpose, namely, **protection and support,** or, to put it more fully, to protect the occupants and contents of the houses from those external influences which might act injuriously upon them, and to provide adequate support for floors and roof.

It is only in lofty or heavy-laden buildings that the question of support needs much consideration. For ordinary brick or stone houses, a wall that is weather-proof will be amply strong enough to carry all the weight which will be put upon it. In exposed situations especially, the question of shelter or protection is practically the only one that requires attention. To fulfil this primary purpose, a wall must be proof against wind and rain, a bad conductor of heat, and durable.

The thickness of the walls has a considerable effect on the dryness and even temperature of a house, but the nature and quality of the materials constituting the walls, and the manner in which they are put together, are also of great importance. The thickness of a wall, in fact, must be varied according to the nature and quality of the materials and the manner of construction. Thus, rubble walls in which the stones are not laid in horizontal beds or courses, are usually specified to be one-third thicker than brick walls or squared-stone walls of the same height.

In order to put some check on the jerry-builder's love of flimsiness, **building-regulations,** prescribing *inter alia* the thickness of walls for buildings of various heights, have been adopted in all towns and cities. The regulations in force in London are somewhat intricate, but, speaking broadly, two-storied houses not more than 25 feet high must have walls not less than 8½ inches thick for the whole height, and three-storied houses must have walls 8½ inches thick for the highest story, and not less than 13 inches for the others. Walls from 40 to 50 feet high must be not less than 8½ inches thick for the top story, 17½ inches for the lowest, and 13 inches between. Walls from 50 to 60 feet high must be not less than 17½ inches thick for the two lowest stories, and 13 inches above. If the walls are unsupported by cross-walls, except at considerable distances, the thickness must be somewhat increased.

The thicknesses just given are for walls built of brick or squared stone, or of Portland-cement concrete properly laid in courses. Random rubble-walls must be one-third thicker. In the case of hollow walls, there must be a wall on one side of the cavity of the full thickness prescribed by the Act.

Of course these regulations are for London only. The by-laws of other cities and towns differ considerably, but in a work of this kind it would be useless attempting to note the different regulations, even of the largest towns. The by-laws in force in any locality must be carefully studied by the architect and builder before plans are drawn or work begun for any houses there. It will often, however, be advisable to adopt a greater thickness than the *minimum* allowed by the regulations; certainly an ordinary brick wall 8½ or 9 inches thick is little protection against cold and rain, especially in exposed situations.

The walls of houses are constructed of various **materials**—stone, brick, terra-cotta, concrete, mortar, wood, tiles, plaster, &c. But in most large towns and cities, the authorities insist on the walls being built of "brick, stone, or other hard and incombustible substances"; wood, valuable though it is as a non-conductor of heat, is too inflammable to be allowed for so important a part of a building as the walls. Of every kind of material there are different qualities—good, bad, and indifferent; and the durability, healthfulness, and comfort of a house depend largely on the proper selection of the several materials. Perhaps there is no part of an architect's work more difficult or disagreeable than to decide as to the acceptance or rejection of materials which the builder has brought to the building-site.

It will be impossible here to enter with any degree of fulness into the varieties of every kind of material used in the construction of walls, but an attempt will be made to give briefly some useful information on the subject.

One general rule may be laid down:—Before adopting any particular material in a building, take care to examine its behaviour in one or more buildings in the immediate neighbourhood. This perhaps is particularly applicable to stone and brick, but it will prove useful in other cases too.

And a second rule is:—Be chary of adopting new materials, or of using known materials in localities where they have not before been adopted. Had Sir Gilbert Scott acted upon a rule like this, he would not have specified Bath stone for the beautiful church at Haley Hill, in smoky Halifax, nor would the vicar and churchwardens have been called upon to "restore" the church within a few decades of its erection.

But while bearing this rule in mind, we must not run to the opposite extreme and resolutely ignore all new materials or new adaptations of old ones:

> "Be not the first by whom the new are tried,
> Nor yet the last to lay the old aside".

1. *STONE.*

Stone is first of building-materials in order and in rank. But there are many varieties and many qualities, from green jasper and peach-blossom marble to such a stone as the spiteful bishop dreaded for his tomb,—

> "Stone—
> Gritstone, a-crumble! clammy squares which sweat
> As if the corpse they keep were oozing through!"

The principal varieties may be roughly classified as *granites*, *marbles*, *limestones*, and *sandstones*. Other kinds of stone, such as slates, flints, and various igneous rocks, are also used in the construction of walls, but chiefly in the immediate neighbourhood of the quarry or pit where they are obtained.

The use of **granite** and other igneous rocks in buildings, except in the neighbourhood of the quarries, is almost invariably restricted to ornamental features. The best granites are extremely hard, non-absorbent, and durable. In consequence of their hardness and the remoteness of the quarries, the cost of polished granite in our towns is invariably high. One disadvantage of the material is its cracking and crumbling away under heat.

Marbles, like granites, are chiefly used for ornamental purposes. They are hard, crystalline limestones, often beautifully figured, and capable of taking a high polish. The best varieties are too expensive for general purposes of construction, and, as in the case of igneous rocks, the other kinds are seldom used far from the quarries.

Limestones are an important class. The best-known varieties are "Bath stone" and Portland stone, the former (speaking generally) being quite unsuitable for outdoor use in the smoky air of towns, while the best beds of the latter have withstood the atmosphere of London with remarkable success. To some persons, the peculiar blackness and whiteness so characteristic of Portland stone buildings—for example, St. Paul's—are objectionable, but after all, these are better than the all-pervading Stygian blackness of sandstone as exemplified in our northern towns, say in the town-halls of Leeds, Halifax, and Manchester.

Other well-known oolitic limestones are obtained from Doulting (Somersetshire), Painswick (Gloucestershire), and Ancaster (Lincolnshire), and a hard and most durable carboniferous limestone is quarried at Hopton Wood, near Wirksworth, in Derbyshire. Magnesian limestones occur at Mansfield in Nottinghamshire, Anston in S. Yorkshire, and Bolsover Moor, near Chesterfield, in Derbyshire.

The **sandstones** used in building are obtained chiefly from the Triassic, Permian, and Carboniferous formations. The *Triassic* rocks are frequently of a red colour, and are not noted for durability; they are quarried in Shropshire, Staffordshire, Cheshire, and some other counties.

Many of the *Permian* sandstones are also red, such as those quarried in the neighbourhood of Penrith, and at Corsehill and Lockerbie in Dumfries. Some of the English stones of this formation have not the best of reputations, and architects will watch with interest the behaviour of the Cumberland stone used by Mr. Basil Champneys in the Rylands Library recently built in the very midst of Manchester.

Undoubtedly the best sandstones come from the *Carboniferous* group. Gloucester, Yorkshire, Lancashire, Durham, Northumberland, and Edinburgh, are counties well known for their carboniferous sandstones. The stone in this group varies greatly, from the coarsest millstone grit to the finest freestone and flagstone, but the freestone obtained from the well-known quarries near Bristol and in the West Riding of Yorkshire, and at Craigleith near Edinburgh, is close-grained, hard, and extremely durable; such stone is better able to withstand the smoky and acidulated air of towns than any limestone, and has the advantage of being more fire-resisting.

It is impossible in the space at my disposal to say more about the different kinds of building-stone, but one important point affecting the durability of stones and their suitability for the walls of houses must be mentioned. I mean their **capacity for absorbing water.** An absorbent stone is more likely to decay than one less absorbent, and will also render a house more damp and cold. In the Appendix a table will be found giving the total absorption and the *rate* *of absorption* (a most important point) of various limestones and sandstones. It will be noticed that, speaking broadly, the limestones absorb a greater percentage of water than the sandstones, and also absorb it more quickly. The Weldon oolitic limestone *in one second* absorbs practically its full quantity of water.

A quick rate of absorption shows that every shower of rain must penetrate far into the stone, and so materially add to the dampness and coldness of the wall in which it is used. On the other hand, stones possessing a slow rate of absorption are scarcely affected by a passing shower, and only long-continued rain can render the walls built of them damp.

Stone Walls.—Building-stones, whether of sandstone, limestone, or granite, are named according to their shape and finish. The principal classes are three, namely, *rubble*, *squared rubble*, and *ashlar*, but each of these has several subdivisions.

Rubble may be *uncoursed*, or (for better work) uncoursed but with hammer-dressed joints, a variety of rubble generally known as *rustic* work; when flints are used they may be laid entire, or "polled", and laid with the fractured surfaces outward, the latter making the neater and better work.

The strength and imperviousness of rubble walls depend very much on the quality of the mortar used. If this is not good, the wall is bound to be more or less a failure. Much rubble is an inferior kind of stone, coarse, porous, and friable; on the other hand, flints and the rubble obtained from igneous and some other rocks, are exceedingly dense, non-absorbent, and practically proof against atmospheric attacks. With mortar of the best quality, used in sufficient quantity, walls built of good rubble are undoubtedly satisfactory and durable. Frequently rubble walls are finished externally with stucco, Douglas being a well-known example of a rubble-and-stucco town.

The angles of rubble walls, when these are not finished with stucco, ought to be formed with squared rubble, or ashlar, or good bricks.

Squared rubble gives a better and neater kind of wall than random rubble. Frequently, as in the case of the well-known Yorkshire wall-stones, the rock splits naturally along the planes of bedding into courses from 2 to 6 or even 8 inches thick, and the slabs are "nicked" to the required width (usually 6 inches) and roughly squared at the ends. The Yorkshire wall-stones are finished on the face principally in two ways, known as "straight-face" and "pitched-face", the latter (shown in fig. 35) having a rough projecting face formed with hammer and pitching-tool or chisel. The pitched-face wall-stones are usually more expensive than the others, but they catch dirt and rain, and are therefore more liable to be blackened by the soot and smoke of towns. Flat-bedded wall-stones of this kind, when laid in regular courses like bricks, are known as *regular coursed rubble*.

A variety of squared rubble is known as *irregular coursed*, or *snecked*, rubble; it consists in the use of stones of different depths, all laid with horizontal beds, but with large stones at irregular intervals, breaking the courses of the other wall-stones.

Ashlar wall-stones are of freestone requiring the use of hammer and chisel on beds, joints, and faces. It is unnecessary to describe minutely the different kinds of finish given to ashlar wall-stones; the beds and joints are usually boasted, while the finish of the faces may vary from the rough rock-face known as "pitched", to the finest "tooled" and the smoothest "rubbed".[1] The rougher the surface, the more opportunity does it afford for the lodgment of dirt and water, and the more likely is it to lead to the decay of the stone.

Ashlar should (except in certain exceptional positions) be laid on its natural bed, especially if the planes of bedding are easily discernible. Otherwise, the face of the stone will be likely to crumble or flake off. The ordinary mason is very fond of using one large stone (false jointed if required) instead of several smaller ones, thus saving labour in beds and joints; but in ninety-nine cases out of a hundred the large stone must be laid on edge with the natural bed of the stone vertical; whence comes decay.

Fig. 31.—Wall-stones with Scamped Joints.

The vertical joints of hand-worked ashlar wall-stones and of squared rubble are seldom squared back far enough. Frequently the appearance of two adjacent stones, seen from above, is as shown in fig. 31; unless such joints are all thoroughly flushed with good mortar (and how often is this the case?), driving rain is sure to saturate the wall: the wall will be a damp one and much time and money will be spent in attempts (more or less vain) to mend it. Certainly the joints should be squared back from the face not less than 3 inches.

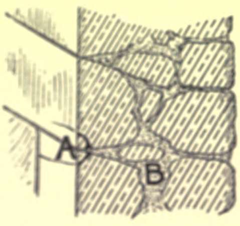


Fig. 32.—Wall-stones with Scamped Beds.

The beds are often worked in the same way, a fault which may lead to the cracking of the stones (as shown in fig. 32 at A) on account of the weight being concentrated on the edge, and also facilitate the ingress of water by forming an inclined plane A B, down which gravity conducts the water to the interior of the wall.

In the days before hollow walls were known, and railways and good roads

[1] Known also as "cleansed" or "polished".

had brought everything everywhere, our forefathers were sorely tried in their attempts to build **dry walls** of porous materials. Among the hills which form the boundary between Lancashire and the West Riding of Yorkshire,—hills whereon fierce wet west winds play till the trees take a permanent "set" to the east,—the difficulty was great. The millstone grit (chief building-stone of the locality), hard and durable though it is, is undoubtedly porous, so porous sometimes that rain is driven quite through the through-stones and bubbles out here and there and trickles down the plaster inside. Having learnt by bitter experience the folly of inward-sloping bed-joints like that in fig. 32, the old builders went to the other extreme, and not content with level beds, often laid the stones as shown in fig. 33. The projecting-joint was always well pointed with mortar. The stone marked A is a through-stone. Many of these old millstone-grit buildings are damp to-day, while some have had their westerly faces covered with oil or other so-called "waterproof" solution, or with stucco or slates.

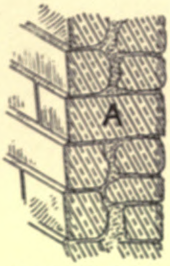


Fig. 33.—Wall-stones laid with Outward-sloping Beds.

Ashlar wall-stones are, of course, a superior kind of stone used only for the face of the wall, the remainder of the wall being built of rubble or brick.

Stone walls are usually built with one "**through**" in every square yard, but as moisture is apt to follow the through, a better plan (where the thickness of the wall will allow) is to have two **bond-stones** in place of the through, as shown in fig. 34 at A and B.

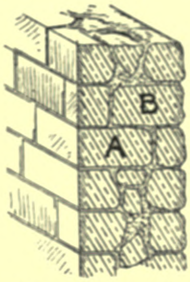


Fig. 34.—Stone Wall with Bond-stones A and B.

Stone-and-brick Walls.—Even in the heart of stone-districts bricks are now generally used for all internal walls, and for all but the facing of external walls. Their cheapness, and the facility with which they can be laid, have led to their adoption in lieu of rubble. Brick walls are also straighter than rubble walls, and require less plaster.

For cottages and small villas, external walls from 12 to 15 inches thick are often used; they consist of an outer skin of stone about 6 inches on the bed, and an inner lining of $4\frac{1}{2}$-inch brick, the space between being either left as a cavity or filled with mortar and scraps of stone and brick. This filling is almost invariably scamped, and, consequently, instead of rendering the wall more solid and impervious, actually facilitates the passage of damp by affording points of contact between the stone and brick. These walls have usually one stone through in every square yard, and two natched or rebated throughs (see fig. 35) to each jamb of door and


Fig. 35. Window Reveal with Natched Through-stone.

window. Sometimes, however, cast or wrought iron ties are used instead of through-stones, and are to be preferred in the case of hollow walls, as stone throughs form bridges, or rather aqueducts, conveying rain-water across the cavity to the brick and plaster within.

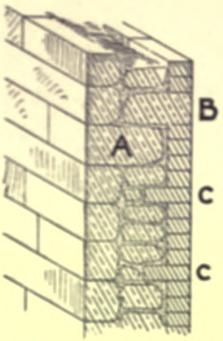


Fig. 36.—Wall with Ashlar Facing, Brick Lining, and Rubble Hearting.

A, outer bond-stone; B, inner bond-stone; C C, brick heading-courses.

For larger buildings, and wherever the additional expense can be afforded, thicker walls should be used. These may be formed as shown in fig. 36, where the heart of the wall is formed with rubble. This gives an opportunity for substituting bond-stones as at A for the through-stones previously mentioned, and the brick lining may be tied to the body of the wall either by inner bond-stones as B, or preferably by rows of headers every fourth or fifth course as at C C. The latter method is desirable where glazed bricks are used, and where the brickwork will not be covered with plaster. The mortar in walls of this kind should be of good quality—made from hydraulic lime or cement if possible,—and the walls will be improved by being run with grout.

Frequently stone-and-brick walls of considerable thickness are simply brick walls with a facing of stone, added for the sake of appearance or to preserve the bricks from atmospheric agencies. In such cases, the thickness of the ashlar courses may be some multiple of the thickness of the brick courses. An arrangement with alternate bonding-courses of stone is sometimes adopted, as shown in fig. 37.

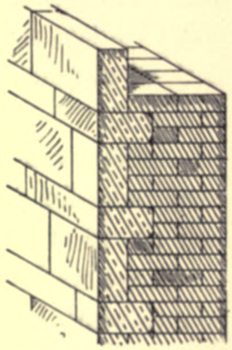


Fig. 37.—Brick Wall with Ashlar Facing having Alternate Bond-courses.

2. *BRICKS.*

The **bricks** of which we have hitherto been speaking have been used for internal work alone, and in almost every locality bricks sufficiently good for this purpose are made. The strength of common bricks of average quality is usually so much in excess of any weight which can be placed upon them in ordinary buildings, that no fear need be entertained of their collapse. And as the internal walls of houses are almost invariably covered with plaster or wainscot or other decoration, no objection can be raised against them on the score of appearance. True, living bacteria have been found in the pores of bricks, and inferior bricks will doubtless provide better accommodation for them than will denser bricks; but as common plaster is much more porous than common bricks, and a better breeding-ground therefore for the organisms, the requirements of sanitary construction will be best satisfied by an improved quality of plaster. Of course, it is not meant that any kind of brick is good enough for internal work, but merely that many bricks may be used for internal work which would be condemned for external work on account of their appearance and inability to withstand for any length of time the attacks of wind, acidulated rain, and frost.

Bricks for external facings, however, require careful selection. There can be no doubt about the durability of good brickwork. On the other hand, there can be no doubt that by far the greater part of the brickwork which has been erected in our towns within the last fifty or a hundred years, already shows unmistakable signs of decay. The railway traveller, as he enters London or any of the large manufacturing towns, has merely to look out of the carriage-window, to be satisfied of the truth of this statement. Wind and rain and frost, and the acids present in the air and rain of these towns, are slowly but surely eating away the arrises and faces of the bricks.

It is strange that no scientific system of tests for bricks has yet been formulated. In the case of Portland cement, engineers, after much disputation and some errors, have laid down certain tests by which the strength and durability can be ascertained, but architects and engineers still judge bricks by rule of thumb and more or less bitter experience. Occasionally the weights required to crack and crush certain bricks are obtained by experiment, but beyond this little has been done.

Here are the characteristics of a good brick, according to the recent utterance of a well-known architect:—

"1. Regularity of shape, so that when built into a wall the pressure is equal over its surface.

"2. Toughness as opposed to brittleness,—*i.e.* it ought not to snap when broken [*sic*], but should require two or three hard blows.

"3. Clearness of ring when gently knocked against another brick, and not a dull, heavy thud.

"4. Homogeneity of surface and texture in the interior, and, above all, absence of small stones and pebbles or lumps of chalk.

"5. Non-porosity,—*i.e.* a slowness in absorbing water."

These five points are undoubtedly well worthy of attention,—far be it from me to detract from them in any way,—but they are not sufficiently definite. For instance, what is meant by a "hard blow"? and what by "slowness" in absorbing water?

Clearly a more definite and less empirical system of judging bricks is desirable, and two tests especially should be carefully defined, namely:—

1. The *total* absorption of water, coupled with the *rate* of absorption.

2. The resistance of the brick to acids (and perhaps abrasion), so that the durability of the brick in town-air and rain may be inferred.

The former test would present no practical difficulties whatever, and the latter would apparently be no more difficult than (say) the hot-water method of testing the soundness of Portland cement.

Two of the most important facts to be ascertained about a brick,—especially a facing-brick,—are undoubtedly the amount of water which it will absorb, and the rate of such **absorption.** The former is important, partly because it affords some indication of the proneness of the brick to produce damp walls, and partly because it shows to some extent the degree to which the brick may be acted upon by rain, frost, &c. The rate of absorption is, however, a surer index of the ultimate dampness of the wall, as a rapid rate means that a wall will become damp with every shower, while a slow rate shows that only long-continued rain will seriously affect it.

Table I. gives the weight of certain bricks, together with their absorption and rate of absorption. It is reprinted from *The Builder* for May 25, 1895, with the addition, however, of a column containing the weights per cubic foot of the several bricks. The results show that, as a general rule, the heavier the brick, the less is the amount of water absorbed. This holds true in almost every case, and it is quite possible that, had the measurements of the bricks been given more exactly, the relation between the weight and absorption would have been even more striking. It appears also that some of the bricks had not absorbed their full quantity of water,—Nos. 1, 3, 4, for instance,—and that if the tests had been continued another week, the ratio between weight and absorption would have held true of these bricks also. Indeed, for bricks whose actual substance has the same specific gravity, the total absorption will vary inversely as the weight, except, of course, in the case of bricks coated with an impervious glaze.

Nothing but an actual test can give the **rate of absorption,** as this depends largely on the nature of the outer skin of the brick. If this be very smooth and vitrified, and free from cracks, the water cannot find easy entrance, nor can the air within the brick escape without difficulty; hence such a brick will have a slow rate of absorption. On the other hand, coarse, soft, underburnt, and fissured bricks may in a few minutes take up nearly all the water they can possibly absorb; notice that in 30 minutes the bricks numbered 7 to 18 absorbed on the average 85 per cent of the total amount. Comparisons may be odious, but they are certainly often useful, and one cannot help remarking upon the superior resistance to damp displayed by bricks 1 to 4.

Table I.

WEIGHT, ABSORPTION, AND HARDNESS OF VARIOUS BRICKS.

No.	Description of Brick.	Locality Where Made.	Dimensions.	Dry Weight.		Absorption of Water per Cent of Dry Weight in					Degree of Hardness.
				1 Brick.	Per Cub. Ft.	1 Sec.	1 Min.	30 Min.	1 Day.	1 Wk.	
			Inches.	Lbs. Ozs.	Lbs.						
1	Wire-cut Metalline,	Buckley, near Chester,	8·9 × 4·2 × 2·5	8 0½	148·5	—	·38	·38	·77	1·16	9
2	Pressed „	„ „ „	8·6 × 4·1 × 2·4	7 7	151·8	·42	·42	·84	1·26	1·26	9
3	Vitrified Plain Paving,	Heathfield, Newton Abbot,	9·1 × 4·4 × 2·0	6 12	143·8	—	—	—	1·38	1·85	8·5
4	Blue Facing,	Ruabon, N. Wales,	8·8 × 4·2 × 2·9	8 9½	136	·36	·36	·36	1·46	2·54	8·5
5	Red „	„ „	8·8 × 4·2 × 3·0	8 13½	137·8	·35	1·06	2·12	5·31	5·31	8
6	Best White Glazed,	Heathfield, Newton Abbot,	8·8 × 4·3 × 2·8	7 9½	123·8	·41	·82	2·88	5·76	6·17	8·5
7	Brook Hill Blue,	Buckley, near Chester,	9·1 × 4·3 × 2·5	7 4	128	1·72	5·17	6·03	6·90	8·18	7·5
8	Flintshire White,	„ „ „	9·0 × 4·3 × 2·6	7 4	124·5	2·15	6·46	8·62	10·34	10·34	7
9	Red hand-made Facing (No. 12),	Bracknell, Berks,	8·9 × 4·1 × 2·5	6 4½	118·9	·49	2·94	10·94	12·93	12·93	3
10	Machine-made wire-cut Red Facing (No. 13*x*),	„ „	9·0 × 4·3 × 2·6	6 9½	113·6	·47	1·89	9·47	13·74	13·74	3
11	Hand-made pressed Red Facing (No. 4),	„ „	8·8 × 4·3 × 2·5	5 15½	109	2·09	7·84	13·61	14·13	14·13	2
12	Red,	Dunton Green, near Sevenoaks,	9·1 × 4·3 × 2·5	6 4	110·4	1·00	4·00	13·50	15·00	15·00	3·5
13	Red Rubber (No. 9),	Bracknell, Berks,	9·8 × 4·9 × 3·1	9 3	106·6	2·04	6·80	13·94	15·30	15·30	1·5
14	White Gault,	Dunton Green, near Sevenoaks,	9·0 × 4·3 × 2·5	6 4	111·6	1·50	6·50	18·00	20·00	20·50	7

A description of the raw materials, and of the **processes of brick-making**, would be out of place here, but it is necessary to point out that bricks may be hand-made or machine-made, the latter being now most common. Machine-made bricks are of two kinds, wire-cut and pressed. In making the former, the clay is forced through a die a little larger than the bed-measurements of the finished bricks,—that is to say, about 9 inches by 4½ inches,—and after leaving the die, is cut into slices about 3 inches thick; wire-cut bricks are therefore without indentations or "frogs". Pressed bricks are each submitted to pressure in a machine before being burnt, and have usually frogs on one or both beds, and often also the name or initials of the maker impressed on them. Pressed bricks, as a rule, are more dense and impervious, and have smoother faces and truer arrises; they are therefore almost invariably used for good external work. The frogs afford a key for the mortar, but are the cause of kiln-cracks in the bricks, and lessen their ultimate strength.

Facing-bricks may be obtained of various **colours**,—white, buff, numerous shades of red, and blue-black,—the colour alone being no guide to the real quality of the brick.

Cutters or rubbers are somewhat soft and absorbent bricks, of a yellow or red colour, prepared from materials of an extreme degree of fineness, and used for panels, arches, splays, and other positions, where the bricks must be carved, or cut and rubbed to shape. They are now being largely superseded by bricks which have been moulded to the desired shape before being burnt, and by terra-cotta, as these are as a rule much more durable, and at the same time—if a considerable number of pieces of one pattern are required—cheaper.

Of ordinary facing-bricks there are so many varieties, and these so constantly changing, that only a cursory glance can be attempted.

Good **white bricks** are made from the gault clay in Kent and Bedford, while some of the best are burnt from the china-clay deposited in pockets among the Devonshire hills. They may also be obtained from several other counties.

The **red bricks** made at Ruabon in Denbighshire are among the best in the country. The Leicestershire and Hampshire pressed bricks also enjoy a good reputation. In all these counties moulded bricks for plinths, sills, string-courses, jambs, and many other purposes are made. Other red pressed facing-bricks of good quality are manufactured at Peterborough, and in Berkshire, Staffordshire, Lancashire, Yorkshire, and other counties.

Staffordshire is the centre of the **blue-brick** industry, the best bricks being produced in the southern part of the county. The peculiar colour is due to the large quantity of iron in the clay. The bricks are not all blue to the core;

usually the middle of the brick is red, shading gradually into the blue, but, whatever the colour, the material should be vitrified throughout. The best Staffordshire bricks are known as "best pressed"; wire-cut bricks are often called "seconds", and are cheaper, and not so dense and true.

Much inferior stuff is now sold as Staffordshire ware,—stuff made of coarse gritty materials, artificially coloured, and warped and cracked in every direction. Quite recently I had to condemn a number of such bricks which had been brought to a building for heavy foundation work; some of the bricks were so badly cracked that one could see right through them.

Good Staffordshire blue bricks are extremely hard, heavy, impervious, and durable, suitable for all situations where great weights have to be carried and damp to be resisted; hence their value for foundations and basement-walls, and for engineering works. Their colour renders them objectionable for the facing of houses above the level of the plinth or base-course.

The best bricks for external facings in towns are undoubtedly "best" **salt-glazed bricks,** those made in the neighbourhood of Leeds and Halifax being of excellent quality.

Salt-glazed bricks are of two kinds, namely, *common salt-glazed* (known also as "seconds"), which are merely ordinary pressed bricks fused on the surface by common salt being thrown into the kiln, and *best salt-glazed*, the faces of which are dipped into a "slip" of the finest sifted clay before being fired and salted. Bricks of the former kind are chiefly used for sewers, manholes, and other places, where a clean impervious surface is required at a comparatively little cost. The "best" bricks, however, are used for external facings, and for internal walls, dadoes, urinals, &c. They are hard, durable, true in shape, and free from surface-cracks, and, being vitrified on the face, they are clean, easily washed, and practically non-absorbent. As the "slip" is of the same clay as the brick itself, the whole is fused into one mass in the kiln, and the glaze cannot shell off as it sometimes does from "enamelled" bricks.

An artistic advantage in favour of salt-glazed bricks consists in their rich and varying colour, which imparts a character and movement to a wall very different from the dull monotony of ordinary (or indeed of enamelled) brickwork. An exceedingly picturesque example of their use—by what architect I do not know —may be seen in Great George Street, London. They have also been used in the plinth of the Clerkenwell town-hall. There can be no doubt that they will be more frequently adopted in years to come.

Enamelled bricks are good pressed bricks which, after being fired once, are dipped several times into "slips" and then into a glaze before being burnt a second time. In the "wet-dip" process the preliminary firing is omitted. They are really bricks to the face of which a porcelain plate (or, in inferior bricks, an earthenware plate) is fused. They are not greatly to be commended for external use as the glaze may fly under stress of weather, but of their advantages for internal work there can be no question. In water-closets, urinals, lavatories, bath-rooms, sculleries, corridors, basements, areas, and other places where dirt and darkness are wont to abide, enamelled bricks may be used with vast improvement of "sweetness and light". They may also be adopted in larders, pantries, and kitchens, and even in dust-bins and the inspection-chambers of drains. The "best" bricks of the best makers are now of such excellent quality that little fear of "shelling" or decay need be entertained.

Bricks with cracked or discoloured faces, or chipped edges, are sold as "seconds" or "thirds", the perfect bricks being known as "best".

Enamelled bricks of several colours can now be obtained,—chalk white, ivory white, cream, buff, pink, and various shades of red, brown, blue, and green. Black bricks are also made, and "soft-glaze" bricks of the nature of majolica. The latter are frequently crazed on the surface, and are not considered as durable as hard-glaze bricks. Enamelled moulded bricks are also made, and also bricks with patterns printed in one or more colours.

Faience is a name which has been applied to a kind of glazed brick and tile. The material has been largely adopted for internal decoration, and in a few instances the external surfaces of buildings have been formed of it. Almost any colour can be produced.

The shape of bricks is a matter of considerable importance. The thickness is not a matter of much moment. Roman bricks were usually more like tiles than modern bricks, being little more than an inch thick, and I have in Spain seen new bricks only $1\frac{3}{4}$ inches thick; in this country, however, the thickness is usually somewhere between $2\frac{3}{4}$ and $3\frac{1}{8}$ inches, although many architects are now in favour of thinner bricks on the score of appearance. The length and breadth are of more consequence than the thickness; in order to obtain proper bond without undue cutting, it is essential that the length of the brick be twice the breadth *plus* the thickness of one mortar-joint, that is to say, if the breadth be $4\frac{1}{4}$ inches, the length should be $8\frac{3}{4}$ or $8\frac{7}{8}$. The reason for this will be apparent on considering the question of bond. Various more or less intricate shapes of brick have at different times been devised, but the common oblong is still almost invariably adopted, except for purposes of ornament.

Brick Walls.—The art of **bricklaying** now demands notice. To ensure a strong wall, the bricks must be so laid that those in one course break joint with those in the course below; in other words, the bricks must be thoroughly bonded together. The bond must tie the wall together both longitudinally and transversely. There are several **varieties of bond,** of which the principal are:—

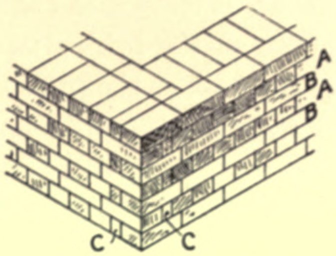


Fig. 38.—English Bond.

1. *English bond* (Fig. 38), consisting of alternate courses of headers A A and stretchers B B; this is the strongest form of bond, and does not provoke scamping.

2. *Garden-wall bond* or *Scotch bond*, consisting of one course of headers to every three, four, or five courses of stretchers; this is a modification of English bond, used chiefly for internal walls.

3. *English cross bond* (fig. 39), another modification of English bond, effected by moving each alternate course of stretchers a half-brick on one side of the other courses of stretchers, so that the joints in the alternate courses are plumb over the centres of the bricks in the other stretching courses; this has rather a pretty effect, and is not uncommon in Holland and Belgium; the Chateau at Spontin, and the Chateau Freyr near Dinant, are excellent examples.

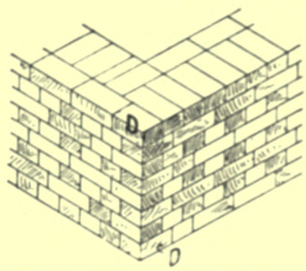


Fig. 39.—English Cross Bond.

4. *Single Flemish bond* (fig. 40), consisting of header and stretcher alternately in each course on one side of the wall, and of alternate courses of headers and stretchers on the other side; this bond necessitates a considerable number of half-bricks or false headers, and is deficient in strength.

5. *Double Flemish bond*, consisting of header and stretcher alternately in each course on *both* sides of the wall; this also is a weak kind of bond, being deficient in headers, and necessitating a great proportion of half-bricks.

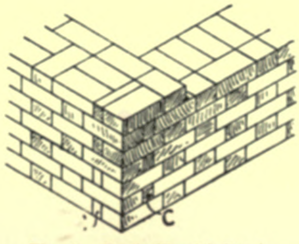


Fig. 40.—Single Flemish Bond.

6. *Stretcher bond* or *chimney bond*, consisting wholly of stretchers, and applicable only to half-brick walls, such as partitions and chimneys.

7. *Header bond*, consisting wholly of headers, and applicable only to 9-inch walls; it is weak and does not look well, but is useful for walls of quick curvature, where the expense of specially-shaped bricks must be avoided.

A glance at the illustrations will show that, in order to make the bricks break joint with each other, it is necessary to insert near the angles narrow pieces one-fourth the length of the ordinary brick, as shown at C C; these are known as closers, and should always be placed next to the angle brick. Instead of the quarter-brick closer a three-quarter brick is sometimes placed at the angle of the wall, as shown at D D in fig. 39.

Sometimes facing-bricks thinner than the bricks used in the remainder of the wall are for æsthetic reasons preferred. It is in such cases impossible to make a really good bond between the two kinds of brick, as headers can only be inserted when the facing and backing have risen to the same level. In fig. 41 this occurs only once in every six courses of face-bricks. If, as will probably be the case, Flemish bond has been adopted, then only alternate bricks in every sixth course will be headers. Thin facing-bricks may, however, be used without detriment for the facing of hollow walls, and also of walls in which a small cavity is formed and filled with asphalt or other composition.

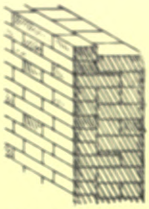


Fig. 41.—Thin Facing-bricks with Common Brick Backing.

For the formation of angles other than right angles, **purpose-made bricks** should be obtained of the desired shape; except of course for rough work, when ordinary bricks roughly cut to the required angle may be used. Bricks with one angle rounded, and known as bull-nosed bricks, are largely used for the salient angles of internal walls where plaster is not adopted; they are especially to be desired in glazed brickwork, as the sharp angle of a square brick is easily chipped by a blow. The shaping of the brick, however, need not be confined to a simple curve; splays, and moulds of various kinds, may be used. In hospitals the re-entrant angles of the rooms are now generally formed curved instead of square, special bricks being used for the purpose; the curve facilitates dusting and washing, and may with advantage be adopted in sculleries, water-closets, and other domestic offices.

Sill-bricks should be jointed with **Portland-cement mortar**; so also should plinths, string-courses, copings, and other projecting members, and the brickwork of parapets and chimney-stacks.

Glazed bricks are often laid in **bricklayers' putty**, which is a mixture of fine white sand or marble dust, and pure lime which has been slaked in a large quantity of water, strained, and allowed to stand till it has become of the consistency of thick cream. Nowadays Portland cement is often used mixed with fine sand, and makes better work. The joints in glazed brickwork, especially in hospitals, are sometimes painted with enamel paint to render them impervious.

As the joints in glazed brickwork are always thinner than those in the brick backing, the glazed bricks should be about one-eighth of an inch thicker than the common bricks, in order that the courses may be kept level and proper bond obtained.

3. *TERRA-COTTA.*

Terra-cotta is a superior kind of brickwork, but possessing in the main the same general characteristics. It is burnt from carefully selected and prepared clay, and may be had of several colours and shades—buff, brown, pink, red, and blue—the red being most generally preferred. The face of the blocks is carefully smoothed with a table-knife or other instrument before the clay is thoroughly dry. This gives a close finish to the surface.

On account of the development of cracks and twists in solid blocks during the processes of drying and burning, terra-cotta blocks, unless of small dimensions, are made hollow, the clay being either forced through a die, forming blocks of a square-channel shape, or filled to a thickness of $1\frac{1}{2}$ or 2 inches into moulds of the desired shape, with clay struts where required to give rigidity to the blocks. After delivery at the building-site, the blocks are **"loaded" with concrete,** which is sometimes composed of only one part of Portland cement to ten parts of coke breeze; this is a very weak concrete, too weak where much weight has to be borne, but in stronger concretes great care must be taken that the cement has been properly air-slaked by being exposed for two or three weeks in a dry building, and occasionally turned, as otherwise the slight expansion of the cement may injure the block.

Of the details of manufacture nothing need be said, but a few hints on the **design and use** of the material may prove of service. The design should not necessitate the use of large blocks; the smaller the blocks the less is the amount of warping in each, and, consequently, the less is the difficulty in fixing the blocks to make neat work. Terra-cotta should always be subjected to compressive stress, not to transverse; for example, it ought not to be used in the form of lintels, but of arches, flat or otherwise. In moulded work, the profiles of the moulds should be such as will allow the walls of the block to be of uniform thickness throughout, otherwise warping and cracks may be developed in drying and burning. "Undercut" moulds especially should be avoided.

Frequently, where **inferior clay** is used, the dried blocks, immediately before being placed in the kiln, are dipped in a thin fine clay, in order that the finished blocks may have a smooth surface and uniform colour. Under certain little-understood conditions of clay and burning, such surface coats are apt to peel off. If dipping has been practised, it can usually be detected by striking the face of the block with a sharp chisel, when some of the thin coat will probably fly off, or at least be revealed, or, better, by gently tapping the end or bed of the block with some hard substance close to the face which has been dipped.

Sometimes a **scum** is formed on the face of terra-cotta during the process of drying. As this would detract from the appearance of the finished work, it is usually removed with brush and water before the terra-cotta is placed in the kiln, but as the formation of scum on the face can be prevented by preventing evaporation taking place through that face, such a damaging process as brushing ought not now to be adopted.

The **durability** of good terra-cotta is beyond question, but, as in all other materials, the quality is by no means uniform, and much terra-cotta is far from satisfactory. Ruabon terra-cotta has been found to absorb water weighing ·51 per cent of its dry weight in 1 second, the same quantity in 1 minute, 1·80 per cent in 30 minutes, and 5·67 per cent in 1 day. No increase took place with a week's immersion. This shows that Ruabon bricks and terra-cotta are of equal quality as regards absorption, and much better than many facing-bricks. See Table I., page 95.

4. *CONCRETE.*

For massive engineering works, such as breakwaters, docks, and sea-walls, and for the foundations of structures great or small, **concrete** has been largely used, but for the walls of ordinary houses it **has not found much favour.** "Several causes have combined to hinder architects from adopting it. Notably among these are the dangers arising from its manufacture by careless workmen and unscrupulous contractors, the difficulty and expense of moulding it to curved and irregular forms, and the bald appearance and unlovely colour of the material itself.

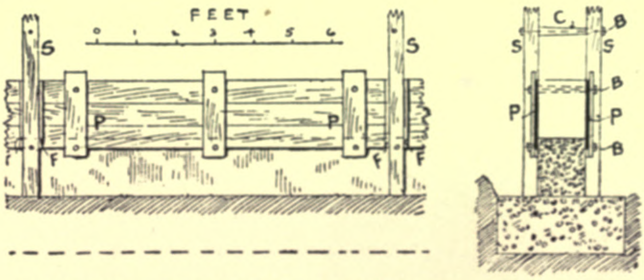
"Other objections to concrete walls are their homogeneity and hardness, which render the hanging of pictures and the fixing of plugs difficult tasks, and which make alterations a costly affair (this last is raised as an objection sometimes, but may perhaps be regarded as an advantage). The ease with which sound is transmitted through concrete walls is certainly a point against them. But it may be said, on the contrary, that good concrete is considerably less pervious than brickwork and some kinds of stone, stronger and more durable, and, under certain circumstances, cheaper."[1]

[1] *Concrete: Its Nature and Uses*, by George L. Sutcliffe, A.R.I.B.A.

Materials.—For the matrix of concrete for external walls Portland cement is by far the most satisfactory material. The best cement only must be used—finely ground, strong, and sound.[1] The sand must be sharp, free from saline, clayey, and organic matter, and not too fine; and the aggregate must be hard, impervious, angular, clean, and not too uniform in size. As the absorption and perviousness of concrete depend largely on the nature of the aggregate, soft bricks and coarse-grained porous stone must not be used. If good results are required, not only must the cement be of the best, but also the sand and broken stone, and the materials must be separately measured, and thoroughly mixed together with a proper quantity of clean water. Constant intelligent supervision is also necessary.

The concrete should contain sufficient cement to fill the interstices in the sand, and the combined cement and sand (*i.e.* the mortar) should thoroughly fill the voids in the aggregate. To attain this object, the ingredients should be used in the following proportions—1 part of cement + $1\frac{1}{2}$ parts of sand + 3 or 4 parts of suitable aggregate. Poorer concrete than this is often used in walls, but it is not wise to do so, at any rate in exposed situations, unless the concrete is faced with brick or stucco, or some other material. Concrete used in the construction of walls in London is specified by the County Council to be composed of "*Portland cement and of clean Thames or pit ballast, or gravel, or broken brick or stone, or furnace clinkers, with clean sand, in the following proportions, viz. one part of Portland cement, two parts of clean sand, and three parts of the coarse material, which is to be broken up sufficiently small to pass through a two-inch ring*".

Although good concrete is undoubtedly stronger than an ordinary brick wall of the same thickness, the London County Council requires "**the thicknesses of concrete walls** *to be equal at the least to the thicknesses for walls to be constructed of brickwork*". A further regulation is that "*such portions of concrete party-walls and chimney-stacks as are carried above the roofs of buildings* [must] *be rendered externally with Portland cement*".

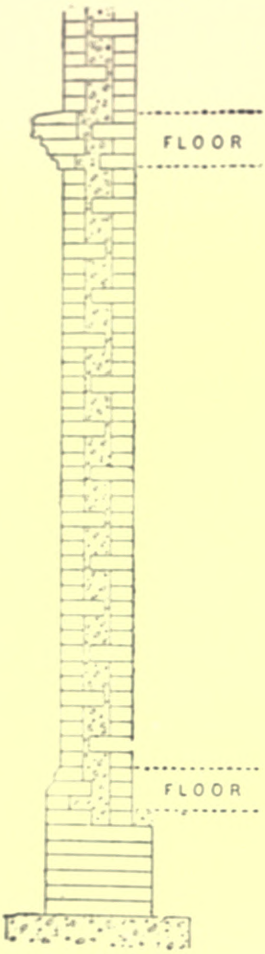


Figs. 42 and 43.—Elevation and Section of Building-frame for Concrete Walls.

Figs. 42 and 43, reproduced from the writer's work on Concrete, give an

[1] See pages 73 and 74.

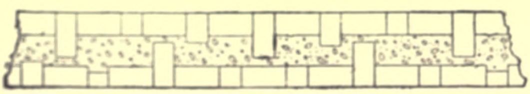
elevation and section of a simple **building-frame for concrete walls;** S S are the standards bolted together in pairs at distances of from 6 to 12 feet, P P are the "shutters" or movable panels of wood, also bolted together in pairs by means of the bolts BB, which pass through wood cores or distance pieces C, these being tapered slightly in order to facilitate removal when the concrete has set; the shutters are kept in position by wood fillets, F F, nailed to the standards. Many different kinds of building-frames have been patented, but the simple arrangement illustrated will suffice for ordinary purposes.



Section.

Inferior concrete must be faced outside with **Portland-cement stucco,** which may be "divided into ashlar" by sunk lines (a bad plan, as the sinkings retain moisture, and lead sometimes to the flaking of the surface-coat), or may be finished in colour with oil paint or duresco.

Concrete blocks are now used to a considerable extent, not only for sea-walls and other engineering works, but also in buildings. For the latter purpose, however, the blocks are often known as "artificial stone", and are used chiefly in the form of "dressings", such as door and window heads, window-sills, moulded string-courses and cornices, panels, finials, and other ornamental work; they are made in various colours, but chiefly red and buff. When properly made of good materials, concrete blocks are sound and durable, but their appearance is not as a rule very pleasing. They are laid like ordinary masonry.



Plan.

Figs. 44 and 45.—Brick and Concrete Wall.

Brick or Stone Walls with Concrete Hearting.—One great objection to the construction of solid concrete walls is the cost and inconvenience entailed by the use of the temporary scaffolding and shutters, and the objection has special force in the case of buildings of irregular shape. **Combined brick-and-concrete walls** have therefore been sometimes adopted, as shown in figs. 44 and 45, the brick skins taking the place of the temporary shutters. Mr. John Gethin, A.R.I.B.A., has used walls of this kind, 15 inches thick, in exposed situations in Wales, and has found them to be not only very strong but also perfectly water-tight. The concrete was composed of one part of Portland cement and five parts of aggregate; the bricks were laid in Flemish bond, all the headers being "snap"-headers, except those shown in the illustrations.

This method of construction can be adopted for thicker walls with greater economy, and, of course, is applicable to stone-faced walls as well as to brick. Such walls cannot harbour vermin, and for this reason are preferable to hollow walls, besides being also less flimsy.

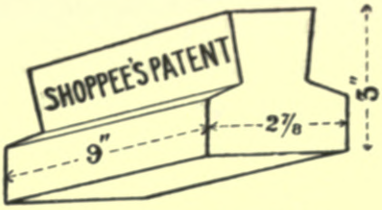


Fig. 46.—Shoppee's Patent Brick.

A special kind of glazed brick, known as **Shoppee's patent brick,** has recently been introduced for use in such walls; no headers are required, sufficient key being obtained by means of a dove-tail projection at the back, as shown in fig. 46. This brick is also used to form the soffits of concrete floors, arched and flat.

The **Cockrill-Doulton Patent Tiles** fulfil the same purpose. They are **L**-shaped tiles, measuring 9 inches by 6 inches on the face, and $2\frac{1}{2}$ inches on the base or bed. A course of tiles is laid on each face of the wall, and the intermediate space filled with soft concrete, care being taken not to disturb the tiles during the operation; and so course by course. As the tiles are glazed, and therefore practically impervious and non-absorbent, walls properly constructed in this manner are likely to be dry and durable, besides being clean and of pleasing appearance. The tiles are made in brown salt-glazed stoneware, cream enamelled stoneware, and with glazes of various colours; and moulded tiles are also made as shown in fig. 47. Quarter-circle tiles are made for the internal angles of walls and for the angles between walls and floors, but in the latter situation—if the floor be of wood—the angle-hollow should be of wood, scribed to fit the tiles above and properly jointed to the wood flooring.

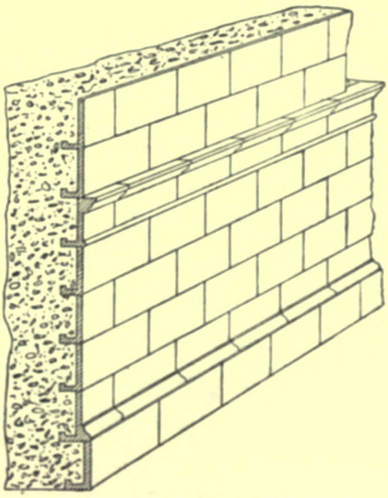


Fig. 47.—Concrete Wall Faced with Cockrill-Doulton Patent Tiles.

Concrete walls may be faced externally with ordinary brick or stone, and internally with these tiles, or *vice versâ.* The tiles are now made with a dove-tail projection along the back, about 2 inches from the upper edge, to give better adhesion for the concrete.

5. *HOLLOW WALLS.*

In exposed situations rain is often driven by the wind quite through a solid wall, especially when the materials of the wall are porous or badly laid. Sometimes the dampness of walls is due to neglect in flushing the joints with mortar, or in the external pointing, but in many cases the moisture is actually driven through the bricks or stones. In stone walls the moisture usually follows the "throughs", and not infrequently these can be counted inside a room by the damp patches on the plaster.[1] Something will be said in a subsequent section on the means to be adopted in order to improve existing damp walls, but for the present we are concerned with prevention, which is easier than cure.

Of course a solid wall can be made impervious by means of a vertical asphalt layer between two skins of brick or stone, as shown in fig. 26, page 80, and in other ways, as explained in connection with basement walls, but, as a rule, quite as effective protection from damp can be obtained at less cost by forming a simple cavity in the wall. Solid walls, however, have certain advantages; they do not harbour vermin, and for the same quantity of materials they are stronger and cheaper.

Theoretically, a **cavity** half an inch wide is to all intents and purposes as effective as one a foot wide, but a narrow cavity is so easily bridged by a piece of brick or a chance dropping of mortar, that a width of not less than 2 inches should be allowed; frequently cavities 2½ or 3 inches wide are adopted.

The **thickness of hollow walls** for small villas is often only 11 inches, that is to say, two half-brick skins and a 2-inch cavity, and where cheapness is a primary consideration this is all that can be afforded. At the same time it must be said that a thicker skin on at least one side of the cavity is preferable, and in London and some other places is indeed obligatory. Thus, the London by-law on hollow walls ordains that "*when hollow walls are constructed, there shall be a wall on one side of the hollow space of the full thickness prescribed*" *for solid walls*; in other words, the total thickness of a hollow wall must exceed that of a solid wall for a similar building by the width of the cavity and the thin skin on one side of it. Clearly in London hollow walls are somewhat heavily handicapped; consequently they are not often used. Indeed it is in the exposed situations of country and seaside, rather than in the sheltered streets of towns and cities, that hollow walls are most needed.

[1] Damp stone-shaped patches, however, are not always due to this cause; they may be the result of condensation, the shape of the cold and dense stones being marked on the plaster by patches of damp, while the warmer and more porous mortar-joints leave the plaster apparently dry.

HOLLOW BRICK WALLS WITH STONE DRESSINGS.

B B. Stoneware bonding-blocks across cavity.
C C. Stoneware ventilating damp-course.
D D. Asphalt damp-course under parapets and gutters.
E. Asphalt on concrete ground-layer.
F. Weathered and throated stone sill.
G. Weathered and throated stone coping.
H. Lead gutter.
I. Lead flat over bay-window.
K. Roof-tiles on horizontal and vertical laths, laid on boards covered with felt.
L. Ordinary laths and plaster.
M. Plaster on expanded metal lathing secured to small steel angles fixed to wood joists.
N. Parquet flooring laid on inch tongued and grooved boards.
O. Wrought-iron casements.
P. Rain-water pipe.
Q. Through-stone course closing top of cavity.
R R. Air-bricks ventilating the floor.

Where a wall 11 inches thick is not sufficient, additional strength is usually gained by increasing the thickness of the skin on *one* side only of the cavity, and the question is often asked, Should the thicker skin form the external face of the wall or the internal? The balance of opinion is in favour of the latter alternative, as in this way the greater part of the whole wall is kept dry, and the floors and roof are more firmly supported; "set-offs" (for reducing the thickness of the wall) can also be more easily arranged without breaking the continuity of the cavity, as shown at A in fig. 48.

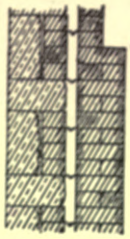


Fig. 48.—Hollow Wall of Stone and Brick.

Several forms of **tubular bricks and concrete blocks** have been devised for the purpose of forming hollow walls, but none has met with general acceptance. Ordinary bricks are so cheap and convenient, and prejudice so strong, that there is little possibility of any patented hollow wall being largely adopted.

In the case of **stone-and-brick walls,** cavities may be formed exactly as in brick walls, an outer skin of stone being substituted for the outer skin of brick, but as ordinary wall-stones vary much on the bed, a somewhat wider cavity ought to be specified. In thicker walls, however, it is customary to build the outer skin of the wall with a lining of brick, the stone and brick being tied together with bond-stones; the inner skin is entirely of brick. A reference to fig. 48 will explain this method of construction.

In **building hollow walls** great care must be exercised that the cavity is continuous throughout the circuit and height of the building. In order to prevent the cavity being bridged with droppings of mortar or brick-bats, battens or iron pipes wrapped with haybands, or haybands alone, should be placed in it, and lifted out when the wall is ready to receive the iron ties or bonding-blocks; the battens or pipes are then laid on the top of these, and the wall carried to the necessary height for the next row of ties, and so on.


Fig. 49.—Hollow Concrete Wall.

Cavities are sometimes formed in concrete walls, as shown in fig. 49, by inserting in the required position between the temporary shutters a 2-inch or 3-inch plank, tapering slightly in thickness from the top edge to the bottom; the taper facilitates the removal of the plank. When the concrete has hardened sufficiently the plank is withdrawn, and metal ties are then laid across the cavity; on these ties the plank rests during the formation of the next layer.

In order to bind the two skins of a hollow wall together and so strengthen the structure, metal **wall-ties, or bonding-blocks** of brick or stoneware, are inserted. Sometimes dense bricks of ordinary shape are used, but as moisture is apt to pass along (if not through) these, it is better to adopt special blocks or ties. Iron ties are from 6 to 9 inches long, and may be either cast, as in fig. 50, or wrought, as in fig. 51. They should be of such a shape as to prevent water passing over them to the inner portion of the wall. When the bricks are without "frogs", the projections under the ends of the ties must be omitted. The cast-iron ties are sometimes rendered malleable in order to prevent them snapping. All metal ties should be galvanized, or dipped in boiling tar and sanded, before being used; otherwise they may rust and injure or stain the wall. Bonding-bricks are usually of semi-vitrified ware. Two good examples are given in fig. 52. That marked A is so shaped that water cannot pass along it or mortar rest on it. The size is $9\frac{1}{4}$ inches by $4\frac{1}{2}$ inches by 3 inches. The bonding-brick B is made by J. C. Edwards, and may be had with $2\frac{1}{4}$ or $4\frac{1}{2}$ inches bearing on the walls, and for cavities 3 or $4\frac{1}{2}$ inches wide. The upward slope prevents moisture passing from the outer to the inner skin of brickwork. Blocks of other shapes can be obtained from other makers. For the sake of appearance the bonding-brick is seldom allowed to show on the face of the wall, as it would not match the colour of the ordinary brickwork; where the outer skin is only a half-brick in thickness, the bond extends into it only $2\frac{1}{4}$ inches, certainly not an amount calculated to give excessive stability.

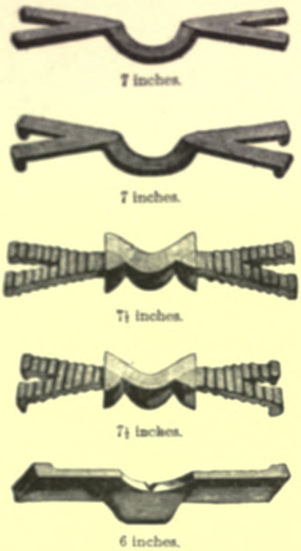


Fig. 50.—Cast-iron Wall-ties.

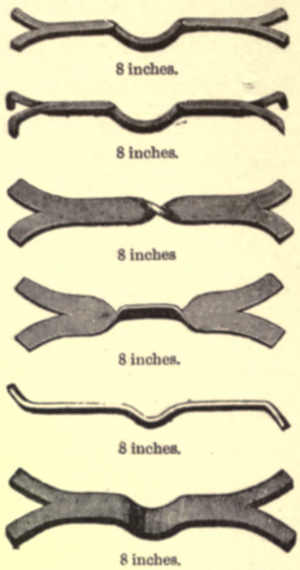


Fig. 51.—Wrought-iron Wall-ties.

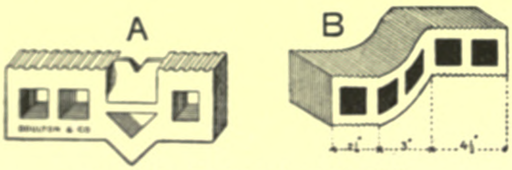


Fig. 52.—Bonding-bricks for Hollow Walls.

Any shortcoming in this respect, however, can be counterbalanced by the **spacing of the bonds.** These, whether of iron or stoneware, are usually placed 3 feet apart horizontally, and 9, 12, or 18 inches apart vertically; that is to say, four, three, or two are allowed in each square yard of the wall.

The general construction of hollow brick walls will be more clearly understood by reference to Plate III., which gives plans, sections, and elevation of

11-inch and 15½-inch hollow brick walls with 2-inch cavities and stone dressings.

The cushion of air in the middle of a hollow wall helps to keep the **temperature of the house** more equable; but this advantage is lost when the cavity is over-ventilated, a condition which may be caused by porous materials, bad mortar-joints, or by excess of air-grates. Holes for egress of moisture are often provided at the foot of the cavity, but if the top of the cavity be closed, as at Q in Plate III., and the wall be well built, little or no circulation of air can take place.

Where parapets and lead gutters are adopted, an asphalt damp-course should be laid on the wall immediately under them, as at D in the Plate.

In order to prevent rain damaging the woodwork of the window or finding an entrance to the room at this point, a strip of 5 lbs. milled lead about 6 inches longer than the head of the window-frame should be built into the wall immediately over it.

A kind of hollow wall is sometimes formed by fixing upright pieces of wood about a foot apart against the internal face of a wall, and covering these with laths and plaster. The uprights may be merely "grounds", about 2½ inches wide and ¾ or 1 inch thick, nailed to plugs in the walls, or may be of larger section (3 inches by 1¾ inches, 3½ inches by 2 inches, or more, according to the height of the room), and fixed quite clear of the wall. The latter is the better method, as there is much less liability of the wood decaying. A more durable construction consists in the use of small steel uprights of L or T section, to which reticulated or perforated sheets of metal, known as "metal lathing", are secured with wire, and afterwards covered with plaster in the ordinary way. Undoubtedly each of these three devices will hide the dampness of an external wall, but in two there is a great likelihood of decay, and in all a cavity is formed for dirt and vermin.

6. *WEATHER-TILING.*

Tile-hung walls have been frequently constructed in recent years, especially for country houses. Buildings in which weather-tiling is adopted usually have the lowest or ground story built entirely of brickwork, the upper stories only being finished with tiles.

Weather-tiles may be rectangular, or may have the lower edges shaped in various ways in order to add to the effect, as shown in fig. 53. The usual size is 10½ inches by 6½ inches by ½-inch, but smaller sizes can be obtained. In the head of each tile two holes are pierced, through which pegs or nails are driven to secure the tile to the laths or wall. Sometimes also there are two projecting "cogs" or "nibs" on the back upper edge for hanging the tile to the wood lath or other projection. The tiles are laid in courses, each course being overlapped by that above; the length of tile remaining exposed is said to be the "gauge" to which the tiles are laid, as at B in fig. 55. For roofs the gauge is usually 3, $3\frac{1}{2}$, or 4 inches, or—to speak in slater's parlance—the tiles (if $10\frac{1}{2}$ inches long) are laid to a "lap" of $4\frac{1}{2}$, $3\frac{1}{2}$, or $2\frac{1}{2}$ inches, lap being the amount by which any course of tiles is overlapped by the *next but one* course above it. For walls the lap is usually less than for roofs, as there is less danger of rain and snow being driven between the tiles. Sometimes the tiles are slightly curved from head to tail, the upper or exposed side being convex, and the other side concave; this is done in order that the tail of the tiles may lie more closely upon those below. The upper part of each course of tiles should be covered with good mortar, to form a bed for the next course. This prevents rattling, and helps to keep the wall warmer and drier.

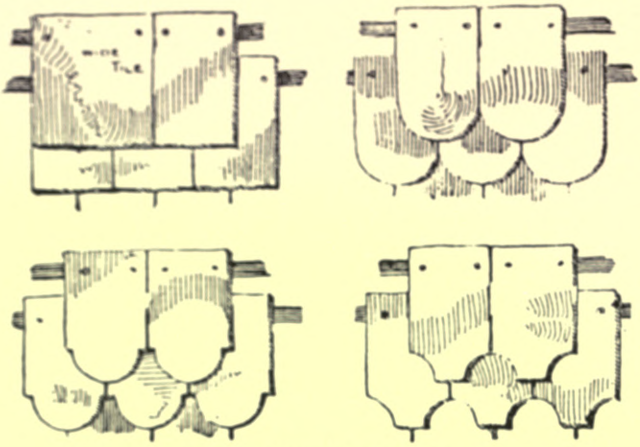


Fig. 53.—Various Shapes of Tiles.

Fig. 54.—Timber-framed Wall covered with Weather-tiling.

Timber-framed walls, as shown in fig. 54, are sometimes constructed to receive the weather-tiling, the framework consisting of horizontal sills or head-pieces with vertical battens or studs framed into them, and struts and braces as required. To the vertical studs, horizontal deal or oak laths (about $1\frac{1}{2}$ inches by 1 inch) are nailed, to which the tiles are secured by pegs or nails. The framework is finished inside with laths and plaster. This arrangement is doubtless as warm and dry as a roof of similar construction, but, as the hollow spaces are likely to harbour dirt and vermin, and as the timber framing certainly adds to the combustibility of the house, the method of construction has little to recommend it save its cheapness. Indeed, the danger arising from these timber-framed walls is so great, that they are forbidden by the building-regulations of most towns and cities.

A warmer and drier arrangement consists in covering the battens outside with boarding and felt before fixing the tile-laths, as in the better kinds of roofing, but this increases the combustibility of the structure and leaves the cavities intact. If the spaces between the studs be filled with silicate cotton or slag-wool, or with brickwork as in brick-nogged partitions, the wall will be cleaner and more fire-resisting. When all is done, however, there is the danger of the woodwork decaying, a danger which was never greater than it is to-day, as never before has there been so much young and sappy wood in the market.

Brick walls furnish a far more satisfactory backing for the tiles. They may be hollow, as shown in fig. 55, or solid, as shown in fig. 56, and the tiles may be secured to the walls directly by means of zinc or galvanized iron nails driven into the joints of the brickwork. The gauge of the tiling will, of course, be regulated by the thickness of the courses of the brickwork, and as this is, as a rule, only 3 or $3\frac{1}{4}$ inches, giving a greater lap than is necessary, the bricks are sometimes laid on edge, and the gauge becomes about $4\frac{1}{2}$ inches. This arrangement is shown in fig. 55, but it cannot be recommended for exposed situations, as it gives a lap of $1\frac{1}{2}$ inches or less. A better method consists in laying the bricks flat as usual, and forming mortar-joints about 1 inch thick, so that the gauge of the tiling will be not more than 4 inches. This is a method adopted by Mr. Ralph Nevill, F.S.A.; the mortar used by Mr. Nevill for the thick joints is made of ashes and selenitic lime, "with a dash of Portland cement". The bonding of the brickwork in this kind of wall is clearly shown in fig. 56.

Fig. 55.—Hollow Brick Wall with Bricks on edge covered with Weather-tiling.

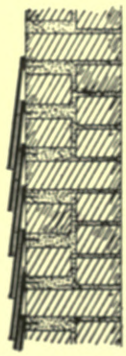


Fig. 56.—Brick Wall with Thick Joints to receive Weather-tiling.

Unless the mortar is of such a nature as to afford good hold for the nails, there is danger of the tiles being stripped by the wind in exposed situations. To prevent stripping, **wood fillets** are sometimes built into the brickwork every six or eight courses, and to these vertical laths are nailed, which in turn receive the horizontal tile-laths. By these means the tiles are securely held, but the wood is sure to decay sooner or later. A better method, which is sometimes adopted, consists in nailing the tiles directly to **fixing-blocks,** specially made of a kind of concrete. Those made by Wright measure 9 inches by $5\frac{1}{8}$ inches by $1\frac{1}{2}$ inches, and are laid in continuous courses alternately with courses of bricks, as shown in fig. 57. The projection of the blocks is useful for supporting the nibs of the tiles, if the tiles are nibbed, but in any case the tiles should be nailed to the blocks.

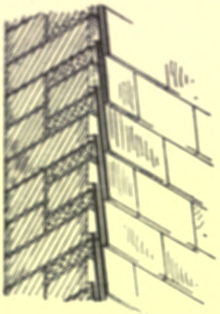


Fig. 57.—Brick Wall with Weather-tiling nailed to Fixing-blocks.

Special tiles, of suitable lengths according to the gauge, are made for the lowest course or eaves, as at A in fig. 55, and also for the top or ridge-course, while the angles of the wall are formed with angle-tiles, known as "square" or "octagonal" according as they are adapted for angles of 90° or 135°. Square angle-tiles for a salient angle are shown in fig. 54. Tiles $9\frac{3}{4}$ inches wide, known as tile-and-half, are used in alternate courses where necessary in order that the tiles may "break joint" (see fig. 53), or half-tiles are used for that purpose.

Great care should be taken that the junction between tiling and window-frames is made thoroughly water-tight with sheet-lead.

A short account of some different qualities of tiles will be found in Chapter VII. of this Section. Suffice it now to say that with good tiles properly laid, brick walls may be rendered warm, dry, and durable. Of the picturesqueness of many old and modern tile-hung houses there can be no manner of doubt.

7. *HALF-TIMBER WALLS.*

"**Half-timber work**" is the name given to that kind of external wall in which a timber framing is exposed to view, the spaces or "panels" between the timbers being filled with brickwork or plaster. Ancient half-timber houses are a notable feature of many country districts in England, and of many of the towns. In London there are still a few examples remaining, as at Holborn Bars, and in many other towns from Exeter to Manchester and Scarborough examples may be found, but the most noteworthy city in this respect is undoubtedly Chester.

At the present time the erection of half-timber buildings is prohibited in London and many other cities and towns, on account of their combustibility. Half-timber work is, however, still largely adopted for the upper walls of country houses. It consists chiefly of a framework of timbers—sills, posts, head-pieces, and straight or curved braces,—securely framed and pegged together. Almost endless variety can be shown in the arrangement of the timbers, and picturesque effects are gained by the projection of the upper stories and gables,

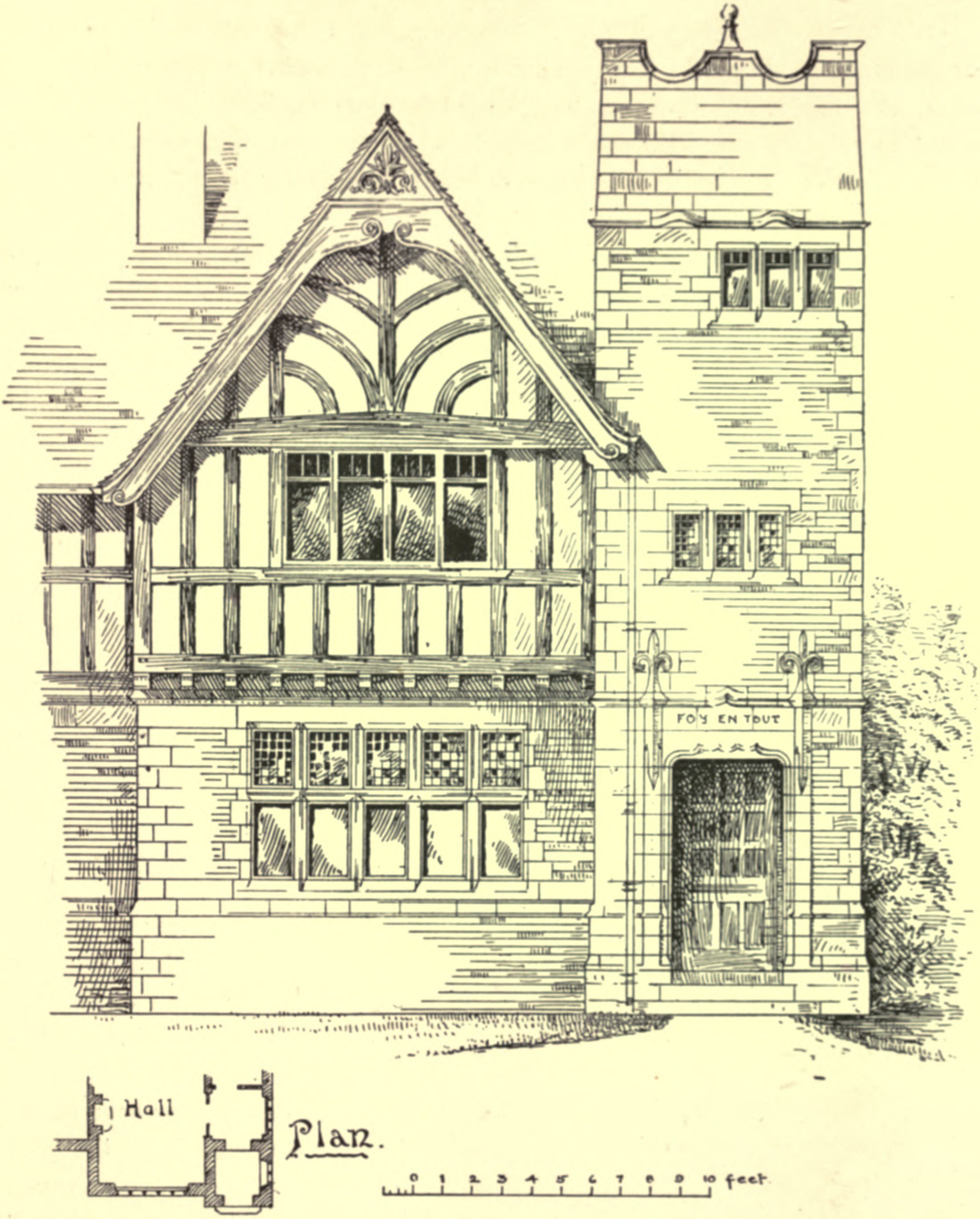


Fig. 58.—Part of Entrance Front of House, with Half-timber Gable, &c.

as shown in fig. 58. The projections have a practical as well as æsthetic value, as they help to keep the walls beneath dry. A common fault is to make the timbers too meagre and the panels too broad, a wiry, restless effect being the result.

Oak is the best material for the framing, but good red deal is cheaper, although not as durable. The joint most frequently used is the mortise and tenon, the half-joint, however, being used at intersections. All the joints should be made secure with oak pegs. The timbers, if of oak, may be coated with oil, but fir is more usually stained before being oiled, or is finished with Stockholm tar or oil paint.

The panels may be filled with **brickwork,** and a 4½-inch or 9-inch brick wall be carried along the back of the timbers, in which case the timbers are merely an ornamental facing to a brick wall. The brick panels may be finished with cement, in order to give the black-and-white effect which is usually the determining factor in the choice of this method of construction. The timbers should be grooved at the sides to afford a key for the stucco. When brickwork is not used, strong wood laths or metal lathing must be nailed between the timbers, and covered with **Portland-cement stucco.** Narrow strips of slate are sometimes used instead of the wood laths, and have the merit of durability. The framing may be finished inside with metal lathing and plaster, or with ordinary wood laths and plaster, or, for better work, may be covered with boards and roofing-felt, to which wood fillets are nailed to receive the laths and plaster.

Undoubtedly the brick filling and backing previously described give the most solid and satisfactory work, the wall being cleaner, drier, more durable, and less combustible.

8. *EXPEDIENTS FOR THROWING RAIN OFF WALLS.*

The soaking of rain into walls may be very largely prevented by various little devices, by means of which the rain blown against the walls is diverted from its course down the walls and thrown clear of the building.

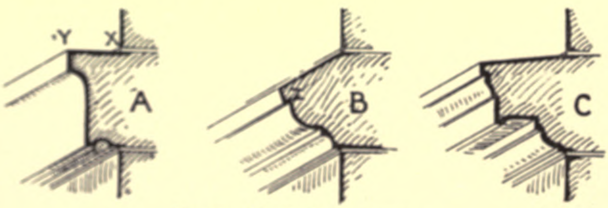


Fig. 59.—Moulded String-courses.

Moulded string-courses, as in fig. 59, will fulfil the purpose. A is a brick section which would have been all the better if the top bed from X to Y had been weathered; it will be noticed that the upper bed of the stone mould at B is shown sharply weathered, so that the water is not conducted into the wall, and that the under surface of the nose at Z is sloped upwards in order that the water may drop freely from the edge instead of following the curve of the mould. The undercut cornice shown at C forms an effectual drip. Moulded string-courses, therefore, are not mere ornamental superfluities; they *are* ornamental, but they are also useful. A cornice or label mould over a window keeps the window drier.

Rain caught on windows should be thrown by the **window-sills** quite clear of the walls below; in other words, the sills must project, and they are all the better if throated also. A weathered and throated stone sill is shown at L in fig. 18, page 56. Fig. 60 gives two brick sills made by the Rowlands Castle Brick and Tile Co.; the throating under the sill A is a great improvement. Sills flush with the wall should not be tolerated, unless there is a moulded string-course under them, which will act as a drip. Sill-bricks should be dense and hard,—blue Staffordshire being the best,—and should be set in good cement-mortar.

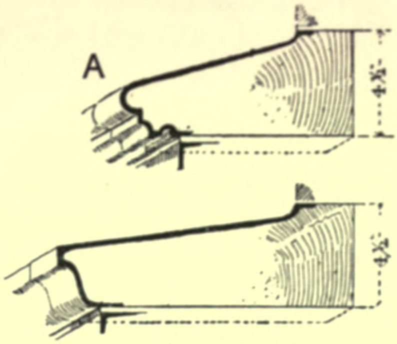


Fig. 60.—Moulded Brick Sills.

Parapets are often the cause of damp walls. They may with advantage be built with cement-mortar, and the coping should be throated and weathered. Stone coping is shown in Plate III., and fig. 61 gives two good forms of brick coping. All parapet copings should be laid in cement-mortar, and the stone coping is all the better if the joints are joggled, as shown in fig. 62. Under all parapets an asphalt damp-course should be formed, as already explained and illustrated.

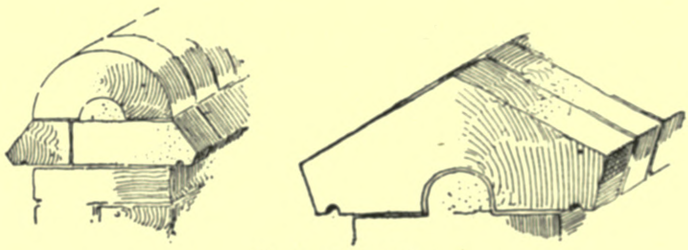


Fig. 61.—Brick Coping.

In half-timber work, and in tile-hung walls, the same principles must be borne in mind respecting the projection of sills and the section of moulds.

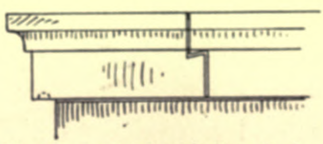


Fig. 62.—Joggled Joint in Stone Coping.

Projecting eaves and gables contribute largely to the dryness of the walls below.

CHAPTER IV.

MORTAR AND STUCCO.

The importance of good mortar can scarcely be over-estimated. If the mortar is bad, the wall is bad. Bad mortar allows wind and rain to penetrate, favours vegetation, easily cracks, and rapidly crumbles away, exposing the arrises of the bricks and stones to atmospheric action, and thus leading to their decay. When the face of a brick decays, it will usually be found that the mortar has first been eaten from the joints; a good mortar-joint not only makes a wall drier and stronger, but also more durable. In vain are the bricks and stones selected if the mortar also is not carefully prepared, and, be it added, used in sufficient quantity to fill the joints.

Unfortunately mortar is easily scamped, and so are mortar-joints, and as long as these matters are left in the hands of jerry-builders and unscrupulous contractors, such will be the case. It is a good plan for the building owner to provide all lime, cement, and sand; then, and then only, may he hope to have them mixed in proper proportions and used in sufficient quantity to flush the joints, and even then he will be disappointed if constant supervision be not exercised, for the ordinary bricklayer can scarcely be compelled to make a solid vertical joint: he scrapes his trowel on one arris of the brick, and leaves three-fourths of the joint absolutely devoid of mortar. Still, the temptation to do this is less when he knows that his master will not grumble at the number of hodfuls which he uses.

Mortar ought to serve at least **three purposes:** it ought to form a soft but gradually hardening bed to receive the various building-materials, so that these shall obtain an uniform bearing notwithstanding the irregularity of their surfaces; in the second place, it ought to prevent the passage of wind and rain through the joints of the walling; and, lastly, it ought to have adhesive and cohesive strength enough to bind the component parts of the wall into one solid mass. Jerry-builder's mortar seldom does more than partially serve the first and second purposes. Only the best Portland-cement mortar will thoroughly fulfil the three.

The by-laws of the **London County Council** relating to mortar are as follows:—"*All brick and stone work shall be put together with good mortar or good cement. The mortar to be used must be composed of freshly-burned lime and clean sharp sand or grit, without earthy matter, in the proportions of one of lime to three of sand or grit. The cement to be used must be Port-*

land cement, or other cement of equal quality, to be approved by the District Surveyor, mixed with clean sharp sand or grit, in the proportions of one of cement to four of sand or grit. Burnt ballast or broken brick may be substituted for sand or grit, provided such material be properly mixed with lime in a mortar mill."

As far as they go, these regulations are satisfactory; but they do not go far enough, as they do not say what is meant by "lime" and "Portland cement". The lime best suited for agricultural purposes is the least adapted for mortar, and yet in many districts the same lime is used in both cases. Indeed, "lime" may mean anything from the fattest of fat limes or the poorest of poor limes to the best ground lias lime, while "Portland cement" may be anything from very bad to very good. Certainly the by-laws are explicit enough to render penal the substitution of "gas-lime" (*i.e.* lime which has been used for the purification of coal-gas) for "freshly-burned" lime, and of filthy street-scrapings and mud for "clean sharp sand or grit",—both substitutions not unknown in the building-trade. It will be noticed also that mortar containing ashes or furnace-clinkers in lieu of sand does not comply with the regulations.

Careful experiments have been made by Mr. Charles Colson[1] to ascertain the **relative values of mortars** containing gray lime, Portland cement, and mixed lime and cement, the briquettes being kept in air. The results are summarized in Table II.,[2] and a column is added showing the relative cost per unit of strength.

In these experiments, three samples of gray lime were used, and were found to vary greatly in strength. The fractured briquettes of the lime-mortar "showed that induration . . . had penetrated only to the extent of from one-eighth to three-sixteenths of an inch, but in the majority of instances to only one-eighth of an inch. The remainder of the area, although dry and moderately hard, had become so mainly from the evaporation of the moisture originally contained in the mass, and in no sense from the absorption of carbonic acid. It was possible, moreover, to crush it in the hand without any great exertion of force."

The loam used in the tests was "yellow, fresh-dug, and rather damp". The quantity of water includes that required for slaking the lime.

The Portland-cement mortars (Nos. 4, 5, and 6) were so raw and harsh "that it would be practically impossible to use them in a satisfactory manner". In order to render them "more plastic and tenacious", lime or loam was added in the remaining tests, to the extent of one-twelfth of the volume of the sand,

[1] *Proc. Inst. C. E.* vol. liv. (1877–78, part iv.).

[2] Reproduced from the author's work on "Concrete".

this being the least quantity that would render the mortars convenient for working. Both these ingredients act injuriously on the mortars, and materially enhance the cost per unit of strength. Loam, however, is much the worse of the two. If we compare tests 5 and 11, we find that the addition of the small quantity of loam lessens the value of the mortar more than 50 per cent. The real economy, therefore, of using *clean* sand—artificially washed if necessary—is evident.

TABLE II.

TENSILE STRENGTH OF GRAY LIME AND PORTLAND CEMENT MORTARS, &c., AT THE AGE OF SIX MONTHS.

No.	Composition by Volume.					No. of Tests.	Average strength in lbs. per sq. inch.		Ratios of strength.	Cost per cub. yd. of mortar.	Relative cost per unit of strength.
	Portland Cement.	Gray Lime.	Loam.	Sand.	Water.					s.	
1	—	1	—	2	1·33	17	27·13	36·88	1	11·83	100
2	—	1	—	2	1·33	27	47·09				
3	—	1	—	2	1·33	27	36·44				
4	1	—	—	6	1·25	15	103·79		2·81	11·56	35
5	1	—	—	8	1·66	20	68·8		1·86	9·93	45
6	1	—	—	10	2	35	50·16		1·36	8·88	55
7	1	·5	—	6	1·5	70	73·47		2	12·2	52
8	1	·66	—	8	2	74	58·94		1·6	10·72	57
9	1	·83	—	10	2·5	85	42·34		1·14	9·75	72
10	1	—	·5	6	1	21	60·8		1·64	11·44	59
11	1	—	·66	8	1·33	25	38·43		1·04	9·82	80
12	1	—	·83	10	2	19	28·66		0·77	8·76	96

It will be noticed that a mortar composed of *one* part of Portland cement, *one-half* part of gray lime, and *six* parts of sand,—a mortar, be it said, which is sufficiently plastic for the bricklayer's purpose,—is, at the age of six months, exactly twice as strong as a mortar composed of *one* part of gray lime and *two* parts of sand, while the cost per cubic yard is practically identical. As far, therefore, as convenience in working, strength, cost, and, I may add, durability, are concerned, the advantage is on the whole greatly in favour of the cement-mortar, but it must not be forgotten that a mortar containing such a large proportion of sand is far from impervious. In any volume of sand, the interstices between the grains constitute from one-third to one-half of the bulk; it follows, therefore, that if cement to the amount of only one-sixth of the volume of sand be added, a large proportion of voids will still remain, and the mortar cannot fail to be somewhat porous.

The wisdom of allowing no more than *four* volumes of sand to be used with cement is manifest, and it is certainly better that even a smaller proportion of sand should be used, or that a certain amount of thoroughly slaked lime should be added in order that the mortar may be more dense. The writer usually specifies cement-mortar to be a 1 to 2 mixture, and never goes beyond 1 to 3.

Excellent mortar can be made from **hydraulic lime,** such as the well-known Lias limes, mixed with sand in the proportion of 1 to 2. The lump or "shell" lime may be used, but the ground lime is much to be preferred, especially where a mortar-mill is not available. The ground lime can be distinguished from Portland cement by its yellow colour.

Selenitic limes are also preferable to common lime, but are not very largely used.

As **sand** (or some substitute for sand) forms the greater part of nearly all mortars, its importance cannot be denied. Certainly pure sand is inert, but much "sand" used in buildings is mixed with clay, iron and other salts, and organic impurities, and is detrimental to the lime or cement with which it is used. In one case about a thousand concrete blocks, in which sand containing iron-pyrites had been used, were quite worthless, as the pyrites destroyed the setting properties of the cement. The salt in sea-sand, when this is made into mortar or plaster, attracts moisture, causing dampness and often leading to efflorescence. The clay in loamy pit-sand may lessen the strength of cement-mortar as much as 50 per cent. Soot in mortar or plaster will cause stains in paint and wall-paper. Organic matter, such as dung in road-scrapings, may lead to the colonization of the house-walls with innumerable micro-organisms, which may be quite harmless or quite otherwise.

Sand from quarries, quickly-flowing streams, and little-frequented roads macadamized with coarse-grained stone, is usually suitable for mortar. Pit-sand is good, if reasonably free from clay and other impurities.

"Sand" from sluggish streams and ditches, from roads macadamized with hard, fine-grained limestone and "granite", and from foundries, had better be rejected; so also must street-sweepings.

The principal **substitutes for sand** are ashes or "breeze", brick-dust, and burnt clay-ballast. Ashes yield mortars of a somewhat weak and porous character, and may interfere with the proper setting of cement if they contain coal-dust or other impurities. Brick-dust and clay-ballast make good mortar, if they are properly burnt, hard and clean.

When a mortar-mill is not used, all **grit and lumps** should be carefully screened from the sand and lime before these are mixed, as they would tend to crack the bricks and stones if used in the mortar.

In making mortar, a little sand more or less does not matter very much when ordinary lime is the matrix, but even in this case the **measurement of the lime and sand** should be carried out with some approximation to accuracy. When, however, hydraulic lime and cement are used, the careful measurement of these and the sand, in suitable boxes or frames, must be insisted on.

Water used in mortar should be "fresh" and clean.

The proper **use of mortar** now calls for notice. It is in vain to have good mortar if it is not properly used. The one flagrant defect in brickwork is usually that the vertical joints are not flushed with mortar. The bed-joints are almost invariably entirely filled, but the ends of the bricks receive the merest scraping on the front edge, while in thick walls the sides of the filling-in bricks may receive none at all. Only the closest supervision of a resolute clerk-of-works can prevent the "brickies" from scamping their work in this way. Mortar made from cement or hydraulic lime must be mixed in small quantities and used fresh. Mortar which has once "set" to any appreciable extent cannot be remixed without loss of ultimate strength.

The **thickness of mortar-joints** in brickwork depends on the regularity of the bricks, the fineness of the mortar, and the care of the workman. In good work the joints are usually about $\frac{1}{4}$ of an inch thick, certainly not more than $\frac{3}{8}$. In stone walls there is more variation than in brick, from the thick joints of rubble and flint work to the ashlar joints scarcely thicker than a penny.

As **water** is absolutely essential not only for the initiation but also for the continuation and completion of the chemical processes involved in the setting and hardening of hydraulic limes and cements, it is imperative that the moisture should not be abstracted from the mortar too soon. Hence the necessity of protecting stucco from brilliant sunshine, or of repeatedly spraying it with water; hence also the necessity of dipping bricks in water immediately before using them, and of sprinkling a dry course of bricks with water before the bed of mortar is spread above it to receive the next course. With lime-mortar also, a moderate use of water in the same way is advantageous, although the lack of it has not so marked an effect as with cement and hydraulic lime.

The method of **finishing the joints** externally, although apparently a small matter, is by no means unimportant. The joints may be finished as the walling proceeds, or may be left rough to be raked out and finished at some subsequent period. To distinguish the two operations, the former is sometimes spoken of as "jointing", while the latter is always known as "pointing". "Jointing" ought always to be adopted unless the mortar is of wretched quality or likely to be damaged by frost. The most common forms of mortar-joints are shown in fig. 63. A is the *flat* or *flush* joint; this joint is often finished by having a jointing-iron run along it while the mortar is wet, leaving an impression as at B, C, or D, according to the shape of the jointer. E is known as the *weather* joint, and is made by pressing the upper part of the mortar into the joint with the trowel. F is the *struck* joint, and is like the last, except that the mortar overhangs the lower course a little. The *cut* or *mason's* joint is similar to the last, but with the lower edge of the projecting mortar neatly cut with the trowel to a straight line; this is the best form of joint, as it protects the wall and does not form a ledge for holding water. H is the *mason's V-joint*.

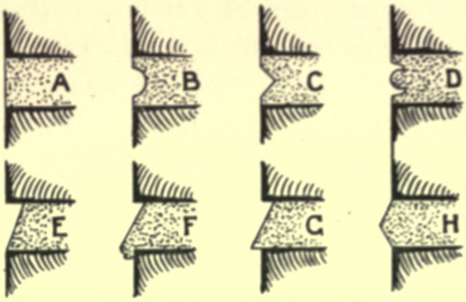


Fig. 63.—Mortar-Joints (full size).

When **pointing** has to be adopted, the mortar should be raked out to the depth of about an inch, and fresh mortar inserted and finished in one of the ways just described. The square projecting pointings, known as *tuck* and *bastard-tuck*, furnish ledges for water, and are soon destroyed; they look neat, but should not be used. In exposed situations pointing should be done with hydraulic-lime or cement-mortar, or with mastic.

The joints of internal walls are left rough in order to afford a better key for the plaster.

In consequence of the difficulty experienced in getting the vertical joints of a wall thoroughly flushed with mortar, it is a wise precaution to have the walls run with **grout** every two or three courses. This is a very thin mixture of lime or cement, fine sand, and water. Ordinary lime is of little or no use, and with hydraulic lime and cement the less sand that is used the better, as the sand tends to settle at the bottom of the pail, and the first part of each pouring may contain most of the lime or cement, and the latter part be nearly all sand. Certainly not more than its own bulk of sand should be mixed with the lime or cement. Besides consolidating and strengthening the wall, the grout has the merit of exposing defects in the jointing by escaping at the defective places, which are at once made good by the workman in order to stop the leakage.

Walls of concrete, rubble, and common brickwork are frequently covered externally with **stucco.** This practice is now more prevalent abroad than in our own country, but the practice is not by any means unknown among us. Formerly the matrix of the stucco was some kind of hydraulic lime, but nowadays Portland cement is almost invariably used, as it hardens better, and is more weatherproof and durable. The cement is made into mortar with two or three times its bulk of clean sharp sand, and applied to the wall as in ordinary plastering. The joints of the wall should be raked out to the depth of an inch to afford a key for the stucco, and the wall should be well wetted before the mortar is applied, lest it should abstract the moisture from the mortar and prevent it hardening. The first coat is scored while wet, and afterwards finished with a second and somewhat richer coat. The whole may be coloured with Duresco, or ordinary oil paint.

Ornamental features can be formed with the same materials, but projecting bricks or stones should be left in the wall to form a key for projecting architraves, cornices, and other details.

At present stucco is out of fashion, but it has its uses, chiefly perhaps in the repair of old buildings; certainly it has rendered many a damp wall dry, and preserved much brickwork which would otherwise have perished.

Rough cast is a covering now seldom used for buildings as a whole, except in the case of cottages and farm buildings, but it is still occasionally adopted for the gables and some other portions of the upper parts of country houses and cottages. It is executed by throwing a very thin paste of hot lime, coarse sand, and grit or fine gravel, upon a wet plastered surface. The whole requires an annual coat of limewash, which may be tinted with ochre or other colouring matter.

CHAPTER V.

INTERNAL WALLS AND PARTITIONS.

Internal walls are occasionally built of **stone or concrete,** but more frequently of **brick,** the thickness as a rule depending mainly on the amount of money available. Brick walls only $4\frac{1}{2}$ inches thick are often used, but certainly a greater thickness is to be desired. Thick walls have the advantages of strength, increased fire-resistance, and of deadening sound.

The word "**partition**" is not easy to define. Formerly it was applied exclusively to structures of wood, such as the ordinary boarded partition, and the framework of wood posts, &c., known as "studding"; but latterly it has been applied to various special kinds of brick and concrete blocks, devised for the purpose of providing light but strong and fire-resisting walls in the upper stories of buildings.

Studding consists of upright wood posts resting on sills secured to the floor-joists or floor-boards, or—in the case of lofty and heavy partitions—to beams provided for the purpose. The studs or posts (for ordinary partitions not exceeding 10 feet high) may be anything from $4\frac{1}{2}$ inches by 3 inches to 3 inches by $1\frac{3}{4}$ inches, fixed about one foot from centre to centre, and braced across to give rigidity. The partition is usually covered on both sides with laths and plaster, like an ordinary ceiling. There are grave objections to these lath-and-plaster partitions: they are inflammable, and easily damaged; they harbour vermin, and transmit sound with great facility. In these days of steel joists, it is an easy matter to substitute a brick wall in almost every case. Certainly studding should not be tolerated between a W.C. or bathroom and a bedroom or sitting-room, or between two bedrooms.

Formerly **brick-nogged partitions** were much in vogue, *i.e.* partitions with the spaces between the timbers filled with bricks, but they are less frequently used nowadays, as it is simpler, cheaper, and better to dispense with the wood framing and to provide a steel joist to carry the brickwork.

Where exceptionally **light fire-resisting partitions** are required, special contrivances may be adopted instead of woodwork; as, for example, pumice bricks, hollow bricks, hollow concrete blocks, thin concrete walls (the concrete composed of Portland cement and breeze). One of these special kinds of partition is shown in fig. 64. It is constructed of fire-resisting blocks 5 feet 5 inches long, 10 inches high, and 2 inches thick, each block having five small holes running throughout its length to reduce the weight. The blocks are secured to floors, walls, and ceilings by means of **U**-shaped metal clamps, and to each other by **Z**-shaped clamps "forced into slits cut by a saw in the adjoining edges of the blocks, one half of the clamp entering one block, whilst the other half enters the adjoining block". The partition is afterwards plastered on both sides, the plaster making the total thickness of the completed partition about 3 inches. The weight of the partition is about one-fourth the weight of a $4\frac{1}{2}$-inch brick wall. Several other partitions of a light but fire-resisting character are also now used, such as Picking's, Shepwood's, and Wright's. Sometimes

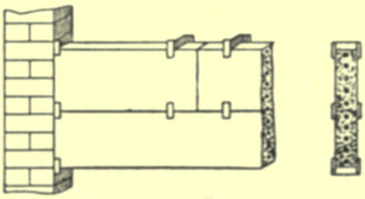


Fig. 64.—"Hygienic" Block Partition.

partitions are formed of two layers of metal lathing attached to the two sides of a very light iron or steel framework, and covered on both sides with good plaster; the plaster forced through the meshes of the lathing renders the partition practically solid. The Expanded Metal Company dispenses with one layer of lathing by erecting a series of tightly-drawn vertical wires and interweaving the sheets of expanded metal horizontally between them; thus, the first sheet will pass in front of the first wire, behind the second, in front of the third, and so on, while the sheet above it will pass behind the first wire, and in front of the second.

CHAPTER VI.

FIREPLACES AND CHIMNEYS.

One of the most important features of a British home is **the open fire.** When properly arranged, this is not only a cheerful and pleasant means of warming a room, but it is also an excellent ventilator, and for this reason a fireplace ought to be provided in every room intended for occupation, especially in every bedroom. On the proper design and construction of the fire-receptacle, and of the shaft for carrying away the products of combustion, the comfort and cleanliness of the room (and indeed of the house) very largely depend. A smoky fireplace, however, leads not only to filth and discomfort; it may also be the cause of colds and sore throats, besides rendering the room unfit for occupation during a great part of the year.

In **the perfect fireplace and chimney** there is a continuous, steady, and not too strong up-draught. The attainment of perfection in chimneys, as in everything else, is a difficult matter. Something must be allowed to skill in design, something to careful workmanship, and something also to happy chance. Here are a few hints which may be of service:—

Firstly, **as to the room itself**—

1. Provision should be made for the inlet of air otherwise than by the door. If there are no chinks in windows, doors, and floors, the fire cannot draw unless the door or window is open: the chimney is not an air-pump.

2. The fireplace should not be too near the door, or there may be puffs of smoke when the door is quickly closed,—not to mention draughts.

3. The fireplace is not well placed against an external wall, for reasons to be given hereafter.

Secondly, as to the fireplace—

1. Dog-grates and hob-grates are apt to smoke on account of the wide open space between the fire and the flue.

2. The old-fashioned register-grates with the outward splay above the flue-opening seem made for the purpose of allowing the smoke to float into the room; the fault can often be cured by the insertion of a sheet-metal hood, as at A in fig. 65.

Fig. 65.—Hood inserted in Register-grate.

3. Hoods are advantageous in connection with all fire-grates.

4. The more fire-clay that is used in the construction of the fire-box, and the less iron, the better.

5. An open space behind the fire-grate communicating freely with the room and the flue—which is often the case with iron grates—is apt to interfere with the proper draught of the fire.

Thirdly, as to the flue—

1. The gathering from the fireplace opening to the flue should be short: a large space at the foot of the flue may make the draught sluggish for some time after the fire is lit. One of Benison's fire-clay smoke-receivers may with advantage be used instead of the usual oversailing courses of brickwork or sloping flagstone; the smoke-receiver, as will be seen from fig. 70, is shaped like a wide, shallow keystone, through which is a hole, large at the bottom, and tapering upwards to the size of the flue above.

2. The flue should not be too large; a flue 14 inches by 9 inches is large enough for all ordinary household fires, kitchen included, and for most fires smaller flues are better, especially if formed with fire-clay tubes.

3. Fire-clay tubes—which are made circular, square, oblong, and square and oblong with rounded corners[1]—increase the draught of a chimney by reducing friction and retaining heat, and also lessen the risk of fire; they should be used wherever the cost can be afforded. The cavity between them and the brick-work should be filled with grout.

4. Where pipes are not used, the flue must be carefully pargeted with mortar and all the angles neatly rounded; this helps to keep the flue warm, reduces friction, and lessens the risk of fire, and of smoke escaping into the rooms or upper fireplaces.

5. Flues against external walls are often chilled by the cold air outside, and draught is stopped in consequence or greatly retarded; hence flues are best

[1] Tubes with two passages (one for smoke and the other for air) are also made, the air-passage commencing in some room which it is intended to ventilate and terminating at an outlet grate in the side of the chimney-stack. It is always better, however, to provide a separate flue for ventilation, as a better outlet can be provided at the top.

placed against internal walls. Where the flue is necessarily against the external wall, the thickness of the wall must not be reduced at the back of the flue, as is so often done, but rather increased, and the flue ought to be lined with fire-clay tubes.

6. Slight bends in flues are an advantage; a perfectly straight flue will draw more fiercely than a curved one, but is more liable to sudden gusts of down-draught. On the other hand, long and sinuous bends must be avoided, especially if the curves approach the horizontal, as the friction of the smoke is considerably increased, and there is danger of the pargeting on the upper side of the bend being scamped. Where the flue makes a smaller angle with the horizon than 45 degrees, soot-doors must be provided.

7. The flue must be unobstructed throughout its length. It is not an uncommon matter for a flue to be partly blocked with mortar, bricks, &c., dropped into it by careless workmen and left there. A good plan is to draw a bundle of hay or rags up the flue as the work proceeds, so that anything falling into the flue is at once stopped. Or the flue may be "cored", *i.e.* a wire brush or other "core" is passed through it after the chimney has been built.

8. One common cause of obstructions in flues is the bad bonding of the flue divisions with the brickwork in front and behind. In many cases there is absolutely no bond at all, and a clumsy or vicious chimney-sweep may easily displace a brick and so throttle the flue. Flue-pipes are advantageous in this respect, as they cannot be easily dislocated; moreover, many flues lined with them never require to be swept.

Fourthly, as to the chimney-stack—

1. The best position for a chimney-stack is on the ridge of the roof, some distance from the gable end. The slope of the roof not far from the ridge is also good, but the apex of a gable and the eaves of a roof are both bad. I do not mean to say that chimneys in these two positions will assuredly be smoky chimneys, but certainly the probabilities are that they will not be satisfactory.

2. A chimney which is overtopped by a building, tree, or rock, in close proximity, is sure to smoke when the wind is blowing over the obstruction, unless an efficient wind-guard at the top of the flue is provided; and what will prove an efficient wind-guard for a particular flue, who can predicate?

3. The walls of chimney-stacks should not be too thin, as thin walls chill the flue and check the draught; this is especially the case with lofty stacks. Here again the flue-pipes will be of service, and the walls may with advantage

be 9 inches thick instead of the usual $4\frac{1}{2}$ inches. When the walls surrounding the flue are 9 inches thick, there is no difficulty in obtaining good bond, but when they are only $4\frac{1}{2}$ inches thick, much neat cutting is required, as shown in fig. 66, which gives two courses of a brick chimney-stack in the usual stretcher-bond. Frequently in stone chimney-stacks with brick flue-divisions, no attempt at bond is made, unless the stone is lined throughout with brick. When ornamental brick stacks are desired, specially-moulded bricks must be obtained, carefully designed to give proper bond, as shown in figs. 67 and 68.

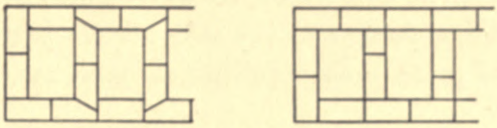


Fig. 66.—Two Courses of 4½-inch Brick Chimney-stack in Stretcher-bond.

4. Short flues are somewhat apt to smoke, a fault often remedied by raising the chimney-stack, or fixing a tall-boy on the top of it. By-laws frequently insist that every chimney-stack must be carried at least 3 feet above the highest point at which it leaves the roof. This is intended as a precaution against fire; it is useful also in increasing the draught of the chimney. In any case, however, the chimney should be carried higher than the ridge of the roof.

5. Each flue should be finished in such a way as to separate it from its neighbours, so that the smoke from one flue does not find its way down the next not in use. This may be done by means of the simple cone-terminal, or short chimney-pot, or by one of the countless host of cowls, pots, and wind-guards. Special contrivances of this sort must sometimes be used, but into a discussion respecting them I may not enter

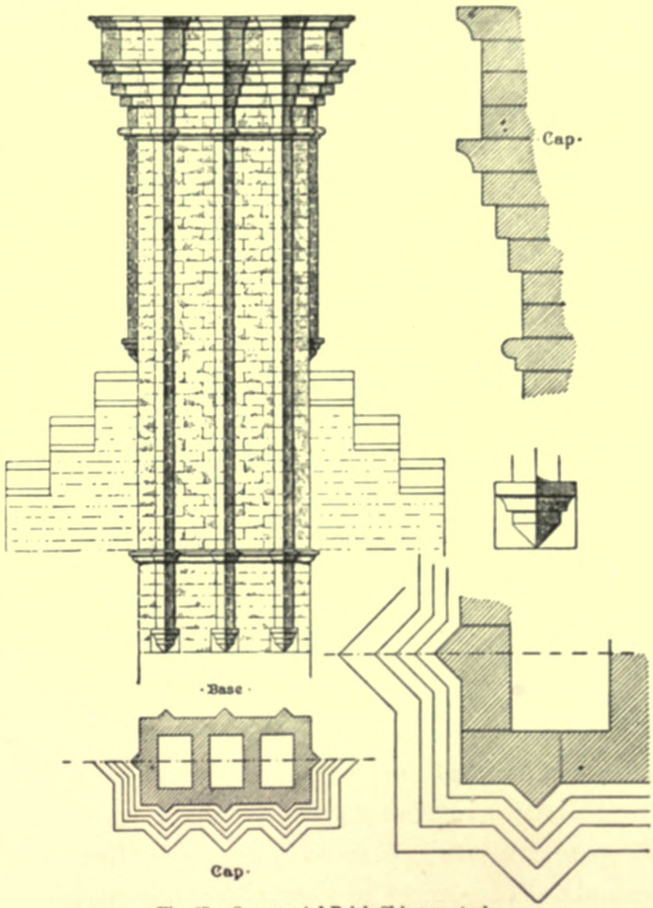


Fig. 67.—Ornamental Brick Chimney-stack.

—space is limited. The inquisitive reader, however, will find descriptions of thousands of them in the Patent Records, if nowhere else.

The subject of **fire-grates** will be treated in the section on Warming, but a few words must be said here respecting them. There are three main varieties of grate, each requiring a somewhat different treatment of the fireplace; these

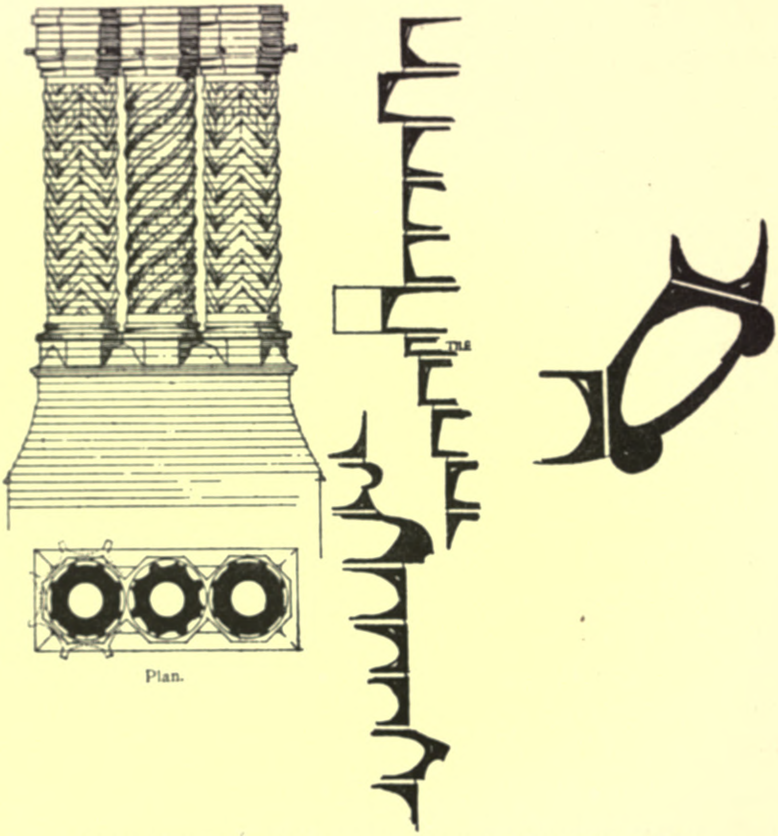


Fig. 68.—Ornamental Brick Chimney-stack, with detached Shaft for each Flue.

are the dog-grate, the hob-grate, and the ordinary grate enclosed on three sides and open at the front.

The **dog-grate**, or (as it is sometimes termed) "fire-basket", is a detached receptacle for fire, placed in a recess, from the top of which the smoke-flue ascends. The grate is usually of iron, with perhaps some portions of brass or copper, and in the better kinds the back and sides are lined with fire-clay. The heat radiated by dog-grates is small in proportion to the amount of fuel consumed, and as they are also provocative of dust, and somewhat apt to smoke, they are not often used except in halls.

The recess for the dog-grate is usually formed with glazed bricks, which are often of small size, measuring only $4\frac{1}{2}$ inches by 2 inches, or 6 inches by 2 inches, on the face, and 3 inches on the bed. The bricks can be obtained of various colours, printed, modelled, or plain, and with square or bevelled edges. Sometimes ordinary unglazed facing-bricks are preferred. Fig. 69 gives a plan and elevation of a dog-grate recess; the width and height of the recess may be varied according to taste or the size of the room; the depth is usually 18 inches. The sides of the recess may be square, as at A, or canted, as at B, the latter being the better form. The brickwork is generally enclosed with woodwork of ornamental design, but faience and marble mantels are sometimes used.

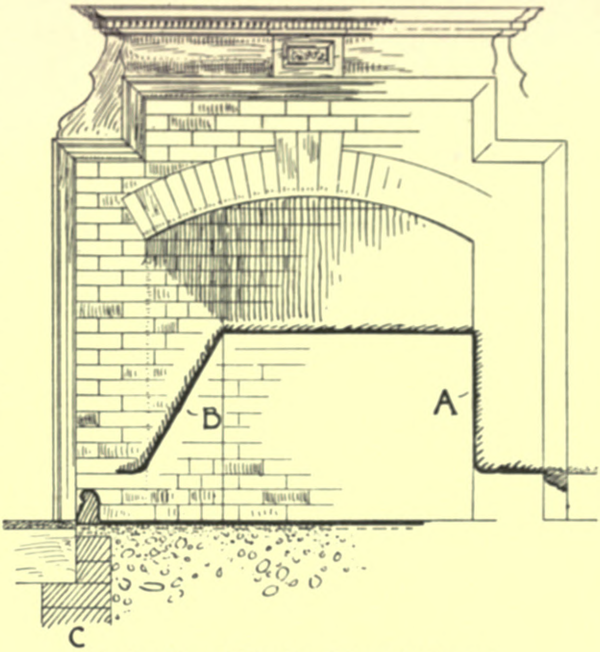


Fig. 69.—Plan and Elevation of Recess for Dog-grate.

The **hob-grate** is closely akin to the dog-grate, and partakes of the family faults. The recess is formed with ordinary brickwork to the top of the hobs, and above with glazed bricks or tiles, or with cast-iron plates, more or less ornamental. The glazed ware has the more pleasing appearance. The breasts and arch may be of similar character to those for a dog-grate; the hob-grate, however, must be accurately fitted to the opening, or *vice versa.* Instead of brick jambs and arch, faience blocks may be used.

The name of the **"ordinary" grate** is legion—from the old-fashioned, cast-iron register-grate to the newest "slow-combustion" fire-receptacle constructed wholly of fire-clay. Ordinarily, a simple opening is formed in common brickwork, as shown in fig. 70, the opening being spanned either by a stone lintel or by a brick arch. The latter is often supported on a $2\frac{1}{2}$-inch by $\frac{3}{8}$-inch wrought-iron bar split at the ends, and turned up and down into the brickwork of the jambs. Into the recess a fire-grate is set, with such brickwork as may be necessary; and the common brickwork around the grate is faced with tiles, or slate or marble mantels, in hundreds of different ways. The recess is usually 3 feet high and 3 feet wide for rooms of moderate size, while for smaller rooms it may be made as narrow as 1 foot 6 inches. In the illustration the brickwork at the back and sides of the chimney-breast is shown 9 inches thick, and that

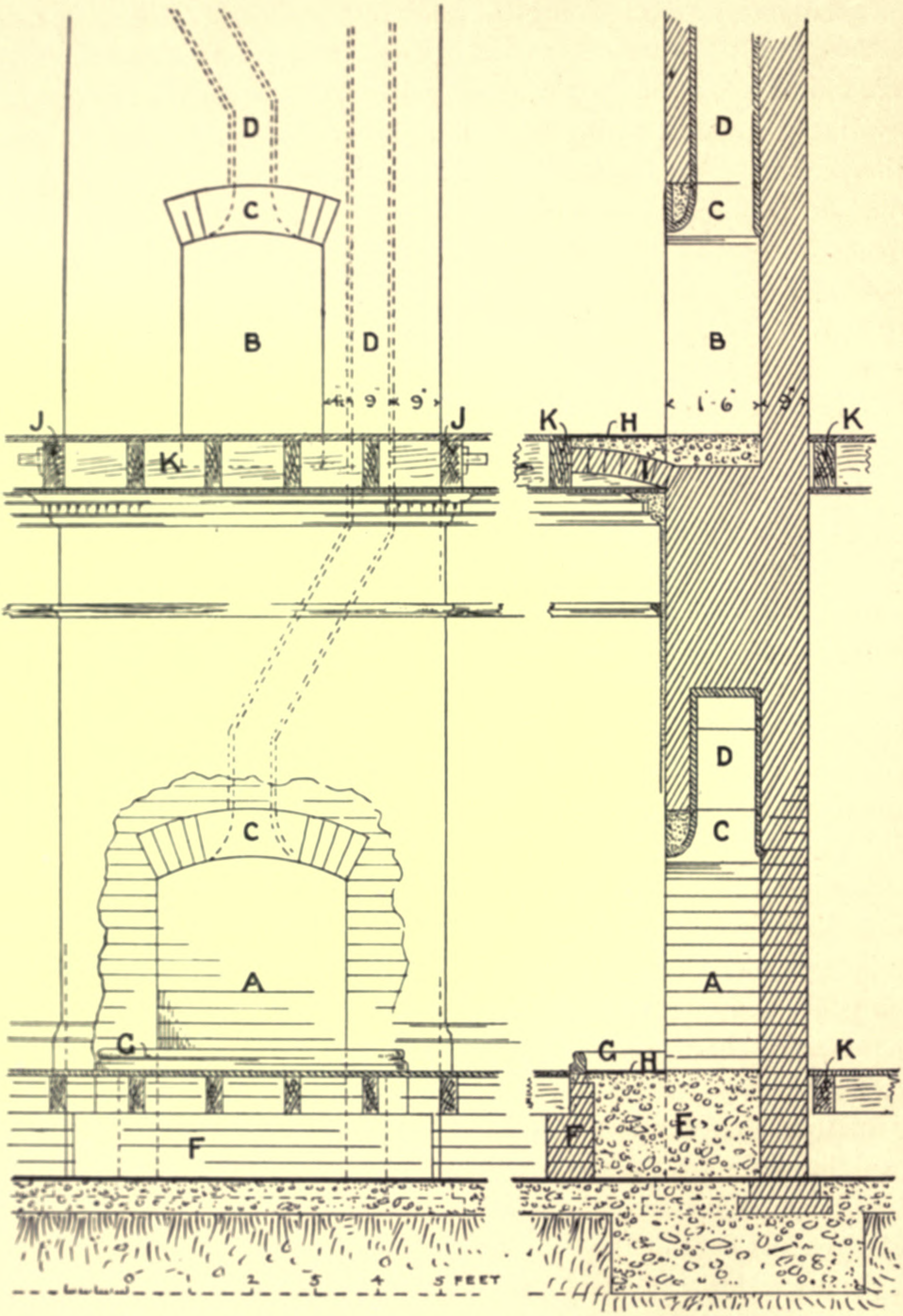


Fig. 70.—Elevation and Section of Chimney-breasts and Flues for Sitting-room and Bedroom.

A, sitting-room fireplace; B, bedroom fireplace; C, smoke-receivers; D, smoke-flues lined with fire-clay tubes; E, solid concrete hearth; F, fender wall; G, fender curb; H, tiled hearths; I, brick trimmer-arch; J, trimming joists; K, trimmers.

in front only 4½ inches, but in good work a thickness of 9 inches should be maintained throughout; this not only lessens the risk of fire, but gives a firmer base for the chimney-stack, and affords a better bond for the flue-divisions.

Many of the glazed-ware mantels and fireplaces are made to fit the ordinary fireplace opening shown in fig. 70, but for some of these a special arrangement of the back hearth is required, as shown in fig. 71, which is a section of the "Rational" fireplace,—a fireplace which possesses several advantages, but which necessitates care in the construction of the hearth when used in connection with wood floors, as great heat is developed under the hearth.

In order to avoid the danger of fire, the brickwork at the back of a fireplace ought to be at least 9 inches thick. When the back is only $4\frac{1}{2}$ inches thick, wood plugs, driven into the joints of the brickwork to secure the skirting on the other side of the wall, may penetrate to the flue, knocking off the pargeting and leaving the wood exposed to the heat of the fire-back. It is particularly necessary to bear this warning in mind when slow-combustion grates are used, as these develop great heat in the back and sides of the fire-receptacle.

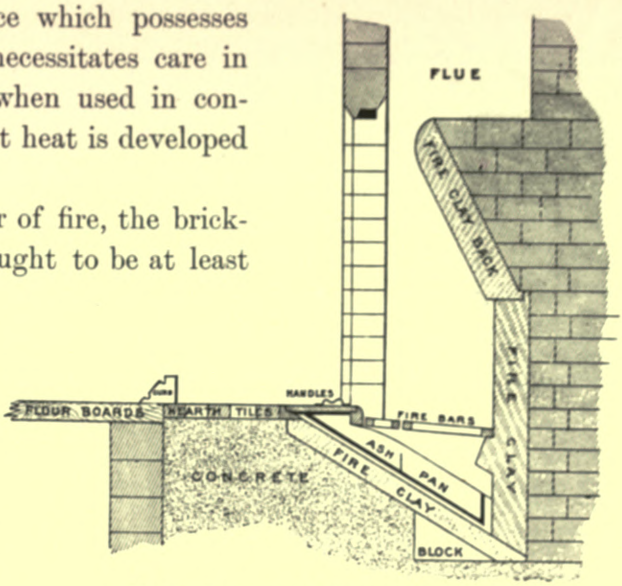


Fig. 71.—Section of the "Rational" Fireplace.

Great care must also be taken that wood **floor-joists and roof-timbers** are not allowed to enter the brickwork of flues and fireplaces. The trimming of the floor-joists in front of a chimney-breast is now never entirely neglected, but it is equally necessary that the joists bearing at the *back* of the breast should also be trimmed, as illustrated in the section in fig. 70. Corbels should be provided for the ends of roof-timbers near flues.

Wood mantel-pieces are also a source of danger. In my own office I was one day surprised by a smell of burning paint and wood, and found that a live coal falling on the hearth had set fire to a piece of paper, and this in turn had set fire to the woodwork of the mantel. Care should be taken that all wood is removed from the metal of the grate by means of tiles or marble slips, the further the better; a glazed-ware fender curb, with the woodwork (if any) extending to the floor outside the curb, is safer than a movable fender.

Wood mantel-pieces, besides being a source of danger from fire, may prove unsightly in consequence of warping and shrinking. To prevent this unsightliness the wood must be of the best, and the mantel must not be delivered at the building for some weeks after the plastering has been completed; indeed, the dampness of the walls is more often at fault than the quality of the wood. Painting the back of the woodwork reduces the amount of absorption from the walls, and, therefore, may prevent warping.

The faulty construction of **hearths** is probably the cause of more household fires than any other defect. When the hearth rests on the solid ground or on the ground-layer of concrete, or when the floor is formed entirely of concrete or other fire-resisting materials, the hearth cannot well be a source of danger; when, however, the floor is constructed of wood joists and boards, danger is inevitably present.

Until recent years the visible portion of a hearth was usually of flagstone in two pieces, known respectively as the "front" and "back" hearth. The back hearth rested on the brickwork of the chimney-breast beneath, while, in jerry-buildings, the front hearth was carried by fillets nailed to the trimmer and trimming joists, or by shallow wood joists extending across the trimmed space. An example of this kind came under my own observation some years ago; the hot ashes from the fire above, passing through the joint between the front and back hearth, *twice* set fire to the pitch-pine ceiling below. Fortunately in neither case was very much damage done, but sufficient at any rate to have paid a dozen times over for the construction of a proper hearth when the building was erected. After the second fire the hearth was bedded on concrete, and no further damage has been done.

Sometimes a counterfloor is constructed under the hearth with shallow wood joists and boards, and covered with mortar or fine concrete, on which the hearth, whether of stone or tiles, is bedded. This is an improvement on the method previously described, but it is not entirely satisfactory. A better and more general form of construction is delineated in fig. 70, p. 130, a trimmer-arch of brick, marked I, being turned from a skewback cut in the chimney-breast to the trimmer, and the space above being filled with cement-mortar or fine concrete, floated to receive the hearth-tiles. A more recent invention consists of a curved iron or steel plate fixed to the trimmer and wall, and covered with concrete, as illustrated in fig. 72. The plates are made 1 foot 3 inches, 1 foot 6 inches, and 2 feet long, and with a span of 1 foot 2 inches and 1 foot 6 inches.

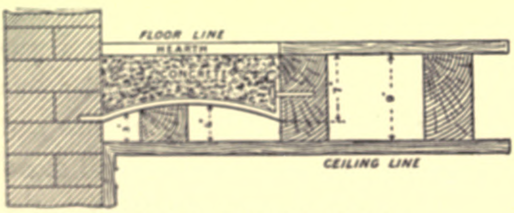


Fig. 72.—Moore's patent Hearth-boxing.

Concrete alone is sometimes used, fillets being nailed to the trimmer and trimming joists, and a chase being cut or formed in the brickwork to support it. The concrete is deposited on a temporary platform of wood, which is allowed to remain in position for a fortnight or more (till the concrete is sufficiently hard), and is then removed.

Hearths in all rooms of any importance are now finished with tiles, which are laid in cement on the floated surface of the concrete below.

The construction of hearths in boarded rooms on the ground-floor is an easy matter. A fender wall of brick is usually built up to the edges of the hearth, and on it the floor-joists rest, as shown in figs. 69 and 70. The space under the hearth is filled with concrete.

Glazed **fender-curbs** of various sizes, colours, and designs are now made, and are frequently used in place of movable metal fenders. They are shown in several of the foregoing illustrations. The ends of the curbs should be ground perfectly true, and secured to each other with dowels, the whole curb being bedded in cement-mortar. It is best to make the concrete hearth large enough to receive the curb; where this is not done, a chase $\frac{1}{2}$ inch deep should be cut in the floor-boards, and clout-nails driven, not quite to the head, in order to afford a key for the cement-mortar.

CHAPTER VII.

ROOFS.

There are **two classes of roofs**—flat and pitched. Flat roofs (so-called) have only the slightest inclination, merely sufficient to allow rain-water to flow to the outlets. They are usually of wood covered with lead, copper, or zinc, or of concrete and other materials covered with asphalt. Pitched roofs have usually a framework of wood or iron or other materials covered with felt, galvanized iron, lead, zinc, copper, glass, slates, or tiles. Pitched roofs are almost invariably adopted for houses in these islands, as they throw off the rain and snow more quickly, and are considered more beautiful. Small "flats", however, frequently occur over bay-windows, porches, and out-buildings. In fig. 73 the *smallest* inclinations which may be given to different roofing materials are shown.

1. *FLAT ROOFS.*

Flat roofs are now being constructed for board schools, blocks of workmen's dwellings, lodging-houses, and other buildings where space for recreation and other purposes is desired; but for small houses, especially in the country, they are seldom used. Frequently the only flat roof in a house is that of the bay-window.

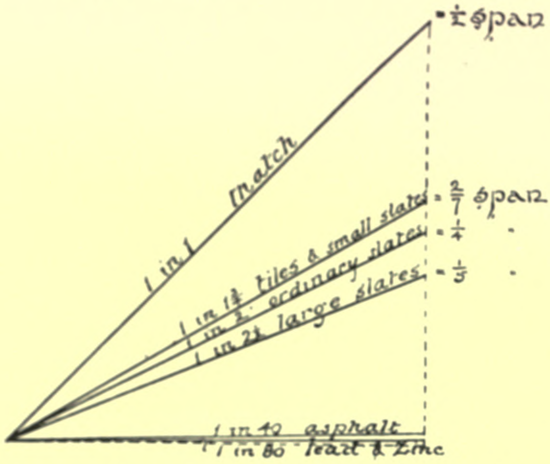


Fig. 73.—Diagram showing the smallest inclination for various roof-coverings.

The framework of a **lead flat** consists usually of wood joists and purlins covered with boards one inch or more in thickness. The boards should be tongued and grooved (in order to prevent warping), of uniform thickness, and laid with their length in the direction of the fall of the flat; where uneven, straight-jointed boards, laid transversely, are used, the lead may eventually be cracked by the edges of the boards. As lead expands and contracts considerably with the rise and fall of temperature, it cannot be simply nailed to the boards like felt, but must be allowed free play; otherwise cracks are sure to occur sooner or

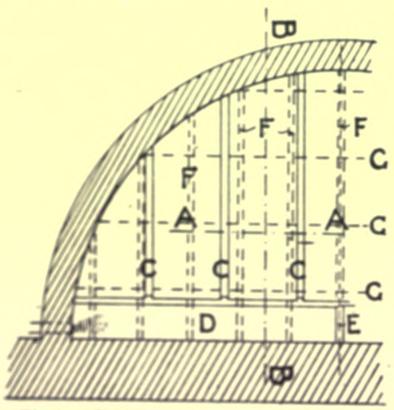


Fig. 74.—Half-plan of Lead Flat over Bay-window. C C, rolls; D, gutter; E, drip in gutter; F F, 9" × 2" tapering joists; G G, 3½" × 3" purlins.

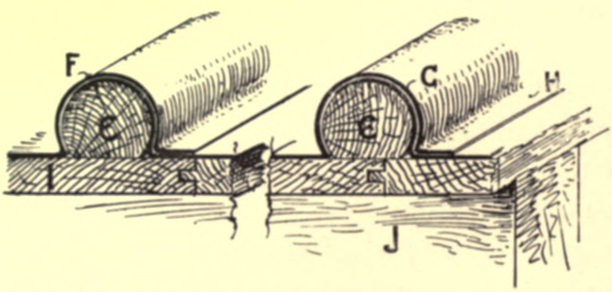


Fig. 75.—Transverse Section through Lead Flat (on line A A in fig. 74). F, undercloak nailed to wood-roll C; G, overcloak; H, splash-lap; I, 1-inch tongued and grooved boarding; J, wood purlin.

later. To allow the necessary freedom, wood-rolls are generally used, as shown in figs. 74 and 75, and the lead is cut into somewhat narrow strips, one edge of the strip being nailed to one of the wood-rolls, as at F, fig. 75, the other edge being dressed over the next roll, as at G, but not nailed or fixed in any way.

The overcloak should extend an inch or more along the flat of the sheet below, as at H.

Wood rolls are usually 2 or 2½ inches in diameter, and fixed at distances varying from 1 foot 6 inches to about 3 feet from centre to centre. Certainly no greater distance than 3 feet should be allowed, and smaller distances are

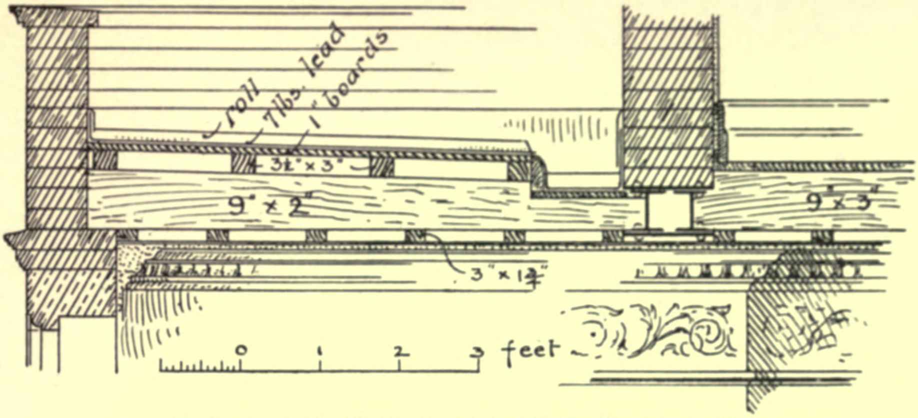


Fig. 76.—Longitudinal Section through Lead Flat (on line B B in fig. 74).

preferable. The sheet-lead is manufactured in various widths up to 9 feet, and the spacing of the rolls should be regulated by the width of the sheet, the size of the rolls, and the overlap of the lead. Thus, sheet-lead 8 feet wide may be cut into three strips 2 feet 8 inches wide. If 4 inches along one edge of each strip be dressed up to form the undercloak on a 2½-inch roll, and 7 inches along the other edge be dressed up to form the overcloak and splash-lap, the flat portion of the strip will be 1 foot 9 inches wide, and this gives the distance *apart* of the rolls, which will therefore be 1 foot 11 inches from centre to centre.

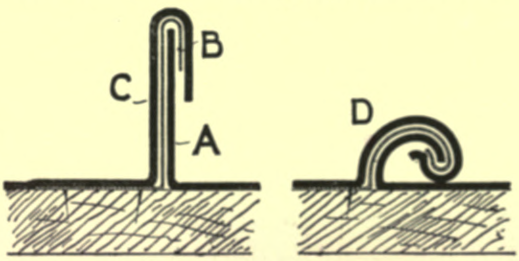


Fig. 77.—Lead Seam-roll.

Seam-rolls are sometimes used. These do not require wood cores, and are therefore adapted for curved surfaces, where the formation of curved wood rolls would be somewhat costly, but they cannot be used where likely to be trampled on. They are formed, as shown in fig. 77, by dressing up one edge, A, of one of the sheets of lead to be united. Tacks or tingles of lead or thin copper, B, are then nailed at intervals of 3 or 4 feet to the boarding alongside the lead, and turned down over it. The edge of the adjacent sheet of lead, C, is set up and turned over till it reaches about half-way down the undercloak. The two edges are then dressed together, and finally bent into the form of a roll, as shown at D, a temporary wood core being sometimes used in the operation. If lead tacks are used, small sinkings should be cut in the boards to receive them.

It is usually said that **the fall or inclination of lead flats and gutters** should be not less than $1\frac{1}{2}$ inches in 10 feet; wherever possible, however, a greater fall should be given, say 2 or 3 inches in 10 feet. A fall of 3 inches in 10 feet is only 1 in 40, not by any means an excessive slope for the conveyance of dirty rain-water and melting snow. Lead is sometimes used for covering roofs of ordinary pitch, but cannot be recommended, as, in consequence of expansion aided by gravity, and contraction opposed by gravity, it gradually "crawls"

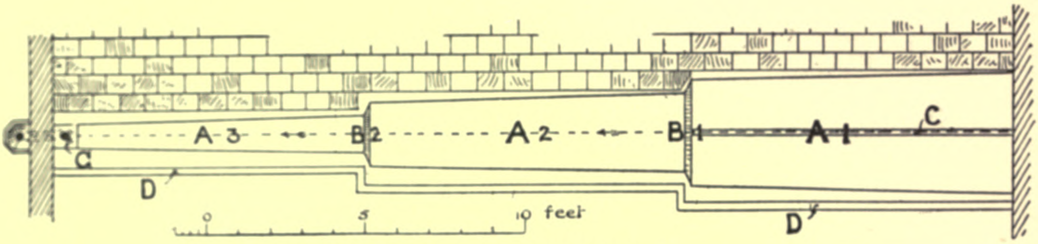


Fig. 78.—Plan of Lead Gutter 30 feet long.

A 1, A 2, A 3, lead "flats" sloping $1\frac{1}{2}$ in. in 10 feet; B 1, B 2, drips 3 in. deep; C, roll; D, tilting fillet for slates; G, cesspool.

down the slope. The lead on the roof of Bristol Cathedral crawled 18 inches in 2 years.

The evil effects of the transverse expansion and contraction of the lead sheets may be avoided by means of the longitudinal joints just described, but the lead may be cracked by longitudinal expansion and contraction if the end or transverse joints are not properly made. Particular care must be observed in the construction of **long gutters**, that the transverse joints are sufficiently numerous, and are not nailed or soldered or fixed in any way. Fig. 78 is the plan of a lead gutter 30 feet long, and fig. 79 the transverse section of the lowest "flat". The transverse joints, B 1 and B 2, are made by means of drips, which must never be more than 10 feet apart, or less than $2\frac{1}{2}$ inches deep. A good form of drip is shown in fig. 80. Care should be taken that there are no sharp angles to cut the lead, and that the boarding is cut out at A to receive the edge of the lower sheet, otherwise a slight ridge will occur, which may result in the cracking of the upper sheet. The upper sheet should extend an inch or more on to the lower flat. In order to economize lead, the drips and fall in long gutters are often reduced to such an extent that solder has to be used in order to make the joints water-tight. This practice is most reprehensible.

In long gutters on roofs of low pitch the uppermost length of the gutter may be so broad that it will not be wise to lay it in one piece. A longitudinal roll-joint is then necessary, as shown at C in figs. 78 and 79. At the outlet end of the gutter a small box or "cesspool" is often formed, as at G, fig. 78, and lined

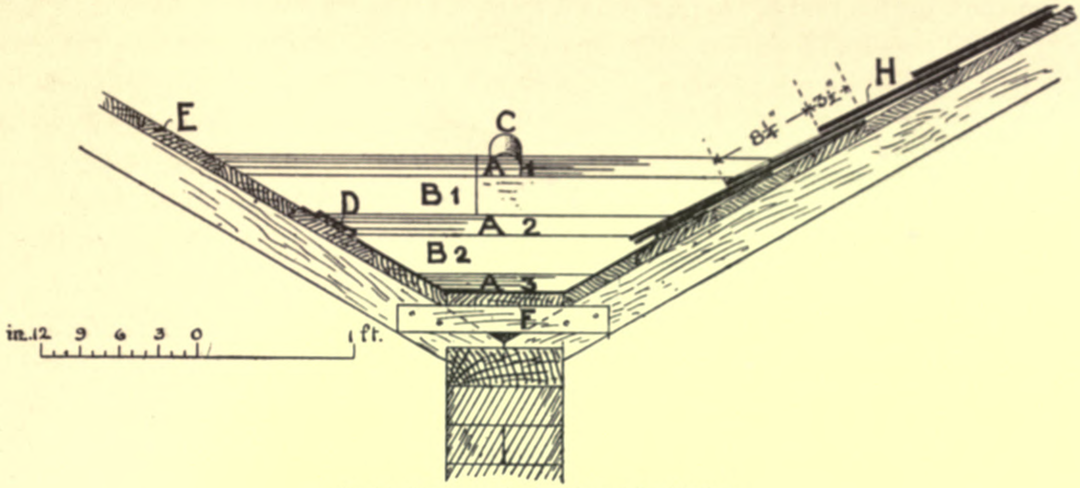


Fig. 79.—Transverse Section through Lead Gutter.

A, B, C, D, as fig. 78; E, roof-boarding covered with felt or waterproof paper; F, gutter-bearer; H, slates 20 in. long laid to a lap of 3½ inches.

with lead, out of which a lead pipe 3 or 4 inches in diameter conveys the water through the wall to the head of the rain-water pipe.

The lead should extend up the roof-slopes to a *vertical* height of not less than 6 inches above the flat portion of the gutter. In roofs of low pitch this entails a great quantity of lead, and it may be advisable to construct a box gutter with vertical sides in lieu of the ordinary gutter.

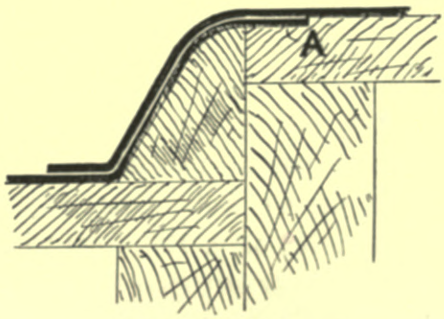


Fig. 80.—Lead Drip.

The junctions of lead flats and gutters with walls and chimneys must be carefully made by means of **lead aprons and step-flashings**, secured into the joints of the brickwork or stonework with lead wedges, and pointed with mastic. The lead used for flats and gutters should weigh 7 or 8 lbs. to the square foot, while that for aprons and steps may be 5 lbs.

Felt is sometimes used under lead flats, as under slates and tiles; but as it is difficult to dress the lead properly on such a yielding material, plumbers prefer it to be laid under the boards and not above them.

Over all gutters in roofs **snow-boards** should be fixed. These consist either of longitudinal bearers to which transverse laths are nailed, or (better) of transverse bearers arched to allow the passage of water down the gutter, and covered with laths laid in the direction of the gutter, as shown in fig. 81. The laths should not be more than $\frac{1}{4}$ inch apart. The object of snow-boards is to keep the snow quite clear of the gutter, and so afford a free passage for water. When the snow rests on the gutter itself the passage of water is impeded, the snow forming a dam, which raises the water over the top of the leadwork and so drives it into the rooms below.

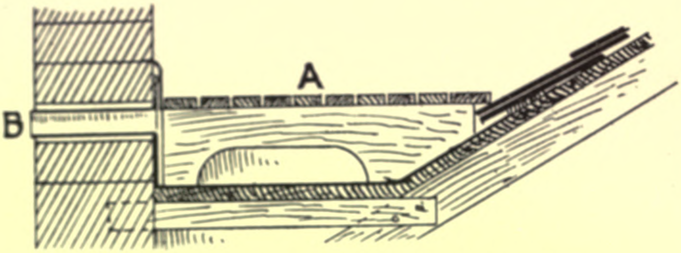


Fig. 81.—Transverse Section of Parapet-gutter with Snow-boards.

A, snow-boards on arched bearer; B, overflow in case the rain-water pipe is stopped.

Zinc is sometimes used instead of lead, being cheap, and is laid in much the same way, great care being taken to allow free play for expansion and contraction. The sheets used for roofs weigh from 1 to $1\frac{1}{2}$ lbs. per square foot, the heaviest being used for flats.

The best zinc is supplied by the Vielle Montagne Company, and this, if properly laid, will last perhaps 20 or 30 years. As a general rule, however, zinc cannot be recommended, as the inferior kinds are soon corroded by the smoky and acid-laden air of towns, and by contact with other metals (iron, copper, lead), and with lime.[1] It is combustible, but has the merit of lightness.

Copper is a far more durable material than zinc, and being used in thinner sheets, it provides a lighter roof-covering. Copper sheets weighing only 16 or 18 ozs. per sq. foot are quite thick enough for flats, and in this respect the material has a great advantage over lead, which ought not to weigh less than 7 lbs. per sq. foot. Some of the characteristics of the three materials are given in the table on p. 139, from which it will be seen that as regards expansion and fusibility, the advantage rests with copper, while in respect of weight it is only slightly heavier than zinc, bulk for bulk. The durability of a sheet of copper weighing 1 lb. per sq. foot is said to be equal to that of lead weighing 6 or 7 lbs., while its hardness renders it suitable for roofs over which there is likely to be traffic. It is laid in a somewhat similar manner to lead and zinc.

Sheets of iron, usually corrugated, are often employed for the roofs of outbuildings. They may be "galvanized" (*i.e.* coated with zinc) or painted. They are never used for the roofs of houses except for temporary purposes.

[1] Cement, however, does not act injuriously upon zinc, and the ill effects of iron are, for a time at least, prevented by galvanizing it.

TABLE III.

COMPARISON OF COPPER, LEAD, AND ZINC.

	Copper (Cu).	Lead (Pb).	Zinc (Zn).
Specific gravity, ...	8·85 to 8·94	11·37	6·86 to 7·21
Atomic weight, ...	63	206·4	65
Weight per sq. ft. $\frac{1}{16}$ in. thick, ...	4·6 lbs.	5·9 lbs.	3·7 lbs.
Melting-point in degrees Fahr., ...	2012°	633°	773°
Conductivity (silver being 100), ...	73·6	8·5	...
Linear expansion between 32° and 212° F.	·00171	·00285	·00297
Relative linear expansion,...	58	96	100
Weight per sq. ft. used for roofs,... ...	1 to $1\frac{1}{8}$ lbs.	6 to 8 lbs.	1 to $1\frac{1}{2}$ lbs.

A kind of flat roof which has been largely adopted in recent years, is really a floor, usually of fire-resisting materials, covered with asphalt. Roofs of this kind, if properly executed, possess several advantages over those already described: they are fire-resisting, undecaying, jointless, and durable, besides affording a surface pleasant to walk upon, and capable of withstanding a considerable amount of wear and tear. A common example of this kind of roof is given in fig. 82, where A A are steel joists, B concrete, C floated coat of cement and sand (1 to 2), D natural asphalt applied in two $\frac{3}{8}$-inch or $\frac{1}{2}$-inch layers, E asphalt fillet, and F asphalt skirting tucked into a joint in the parapet, the joint being first raked out to the depth of an inch, and pointed with cement mortar after the insertion of the asphalt. Such roofs should be laid to an inclination of not less than 1 in 40, and cesspools should be formed in the concrete and covered with asphalt, with lead pipes leading from the cesspools to the heads of the rain-water pipes.

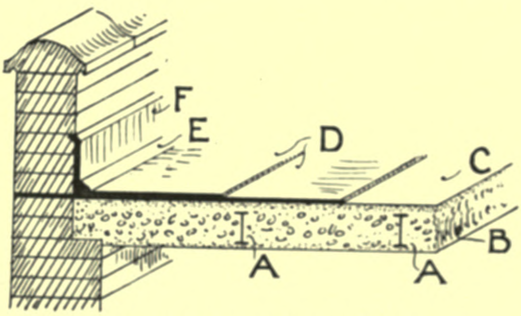


Fig. 82.—Flat Roof of Concrete and Asphalt.

For roofs, artificial asphalts must not be used, as they are too much exposed to the action of the weather, and may become soft in hot weather, and perhaps crack in cold weather or with the slightest inequality in the settlement of the building. I have before me a piece of such "asphalt", which a light kick broke like pot from a roof-skirting, where by command of the building-owner it had been used instead of the natural asphalt which I had specified.

Thin solid roofs, like that illustrated in fig. 82, are not an effectual protection against extremes of temperature, and may with advantage be ceiled beneath with wood or metal ceiling-joists, and wood or metal lathing covered with plaster. The air-space thus formed will increase the comfort of the room beneath. Or instead of the solid concrete, one of the numerous kinds of floor may be used in which hollow lintels of brick or fire-clay extend between the joists. These lintels are keyed beneath to receive plaster. See fig. 89.

Occasionally an ordinary flat of **joists and boards** is formed and **covered with felt and asphalt**, but this cannot be recommended, as—especially if the ceiling is plastered—the wood is almost certain to decay. A modification of this, in which the ventilation of the confined space is considered and the wood boards are superseded by steel webbing, deserves mention. Short fillets of wood are nailed along the top of the joists, but with spaces between the ends to form air-passages; on these steel webbing or metal lathing is fixed and floated over with hair-mortar. When this is sufficiently hard, it is covered with a layer of concrete and a double layer of asphalt. The system is applicable to floors as well as to roofs,—tiles, mosaic, terrazzo, wood blocks, or parquet taking the place of the asphalt.

2. *PITCHED ROOFS.*

Into the details of construction of ordinary **pitched roofs** I do not propose to enter. One or two points, however, may be briefly alluded to. Care must be taken that the ends of roof-timbers do not enter into smoke-flues; neglect of this may result in the destruction of the house by fire. The ribs (or purlins) and other woodwork must be amply strong enough; sagged roof-timbers mean broken slates and tiles, leaks, and insecurity. The space between the top of the wall and the upper side of the common rafters must be thoroughly filled with bricks and mortars, *before* the roof-boarding is laid or the slating begun; this is known as beam-filling, and is often left by the bricklayer to be done after the completion of the roof,—which means that it will be only half-done.

Pitched roofs are usually covered with slates or tiles, but sometimes thin flagstones (known locally as "gray slates" to distinguish them from Welsh slates, which are known as "blue"), thatch, copper, zinc, lead, wire-wove roofing, and sheet-iron (often corrugated and galvanized), are used. Temporary buildings may be covered with tarred felt on boards. Slates and tiles, however, are the chief roofing-materials, and to these we must confine our attention.

Slates are either *stone* slates or *clay* slates.

Stone slates are thin slabs of stone, which have been split along the planes of bedding. Many of these slates are very "beddy", and may be cloven into sheets less than an eighth of an inch in thickness. Such slates should be rejected, as frost may split them. Stone slates are somewhat absorbent, and water does not pass very freely from them; roofs covered with them should therefore be of quicker pitch, say not less than 1 in $1\frac{3}{4}$, or $\frac{2}{7}$ of the span. These slates vary considerably in size and thickness, and must be carefully sorted into groups, each group containing slates of approximately uniform height and thickness. On account of their irregularity a greater lap is necessary than with clay slates; a 4-inch lap is commonly specified. The slates are laid on battens, being hung to them by one or two wood pegs driven through holes in the head of each slate, and the joints beneath are afterwards pointed with good hair-mortar, an operation known as pointing or torching.

Stone slates are heavy, somewhat absorbent but durable, and are warmer than clay slates, but they are not much used nowadays except for farm-buildings, and for repairs and additions to existing houses.

There are two principal districts in which **clay slates** are produced in these islands, namely, North Wales and the English Lake District; but other quarries are worked in Leicestershire, Devonshire, and Cornwall in England, Perthshire and Argyleshire in Scotland, and in Wicklow and Kilkenny in Ireland. Slate is one of the densest and strongest rocks, weighing from 170 to 180 lbs. per cubic foot, and having a crushing strength of 9 tons and upwards per square inch. Good slate is clean, non-absorbent, and practically unaffected by atmospheric agencies.

Welsh slates are of two geological formations, the *Cambrian* and the *Lower Silurian*. The former gives the well-known and excellent Penrhyn and Velinheli slates, and other slates shipped at Bangor and Carnarvon, while from the Lower Silurian formation are obtained the Ffestiniog slates (shipped at Portmadoc), the Llangollen slates, and others. The colour of Welsh slates varies considerably —red and purple Bangor, gray and purple Penryhn and Velinheli, green, blue, dark-blue, and even black. Some of the black slates are of wretched quality, and will break after a few years' exposure; many roofs covered with them have had to be stripped and covered with new slates. Perhaps it would be too broad a generalization to say that all dark or black slates are bad, but they are certainly not above suspicion. A good slate will ring clearly when struck, will not be friable at the edges or holes, will not splinter easily, will be free from dark veins, non-absorbent, straight, and of uniform thickness.

Welsh slates are almost invariably sold in regular sizes, the extremes being 36 inches × 24 inches and 10 inches × 5 inches. The smallest slates undoubtedly make the prettiest roofs, as anyone who has observed the slated roofs and spires of the Belgian Ardennes will testify; but they are seldom used in this country, except for turrets, dormers, and summer-houses. The size most commonly used is 20 inches × 10 inches.

There are generally two or three qualities of Welsh slates: *firsts* are thin, straight, and of uniform thickness; *seconds* are thicker and less uniform; *thirds* are still more irregular. The smooth regularity of a roof covered with *firsts* Welsh slates is far from pleasing; such slates, moreover, are so thin that they are easily broken by anyone walking over them. *Seconds* slates, from which the most irregular have been discarded, make stronger and more pleasing work.

The slate quarries of the English Lake District have during recent years largely increased their output. These slates—which are commonly known as **Westmoreland slates,** although they may be quarried in that county or in Lancashire or Cumberland — are stronger and thicker than ordinary Welsh slates, more durable and of better appearance. Some of them, as the Elterwater, Tilberthwaite, Coniston, and Langdale slates, are of various shades of green, while others, such as those obtained near Ulverston, are blue. They are more expensive than Welsh slates, but are worth the extra cost; the green slates are much in favour now for the roofs of buildings constructed of red brick or terracotta, the contrast of colour being decidedly pleasing. For stone buildings also the green roof is welcome; a stone building with a blue roof has a cold, dull appearance.

Westmoreland slates are usually sold by the ton, and not, like Welsh slates, by the "thousand". And the slates in each consignment vary in size, and must be sorted (as already explained in the case of stone slates) before being laid. The extreme dimensions and "qualities" of Westmoreland slates are not uniform throughout the district, but the following table will be useful as an example; it refers to the Elterwater green slates.

Slates must be so laid that wind and rain cannot pass directly between them. To attain this object, the slates in alternate courses must be laid to break joint as shown in figs. 78 and 83, and the lower part or tail of the slates in any course above the two lowest must overlap the head of the course next but one below it. This overlapping is clearly shown in figs. 79 and 83, and is called the "lap" to which the slates are laid. For steep roofs, and for low-pitched roofs where parsimony prevails, the lap is often no more than 2 inches; indeed jerry-builders reduce it to 1 or $1\frac{1}{2}$ inches. For good work, however, the lap should be 3 or $3\frac{1}{2}$ inches, and in exposed situations a 4-inch lap is often necessary.

TABLE IV.

ELTERWATER GREEN SLATES.

	Quality.	Price per Ton.	Computed to Cover
			Sq. Yards.
L	Best slate, 36 in. to 20 in. long, proportional widths, ...	95/-	25 to 30
	Best slate, 20 in. to 12 in. long, proportional widths, ...	90/-	
C	Second slate, 30 in. to 12 in. long, various widths, ... (Recommended for colour, which is equal to best.)	65/-	22 to 25
P	Best Peggies, 14 in. to 7 in. long, ... (Equal to first quality in texture and colour.)	70/-	25 to 30
P	Second Peggies, 12 in. to 5 in. long, ...	40/-	22 to 25
T	Thirds, 30 in. to 12 in. long, various widths, ... (A strong slate suitable for mill work, farm out-buildings, &c.)	40/-	18 to 20

Before the slates are laid they must be **holed for nailing**. Each slate, unless it is of very small size, must have two holes, which may be either in the upper corners of the slate as shown at A A, or near the middle of the sides as shown at B B. Objection is sometimes taken to the latter position on the grounds that moisture may be driven through the nail-holes, and that the nails may be injured by the moisture. Neither ground of objection has much importance, and as the slates are certainly more securely held when nailed in the middle, and less liable to be broken and stripped by the wind, side-holing is becoming more common. The exact distance of the holes from the tail (or lower edge) of the slate is important.

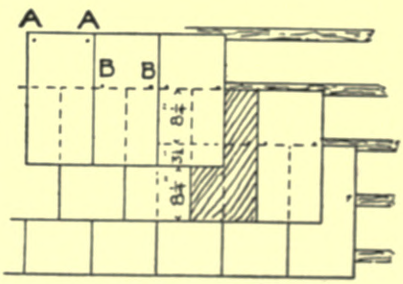


Fig. 83.—Plan of Slated Roof.

Slaters are apt to take it as the measure of the lap; thus, if slates 20 inches long are specified to be laid to a lap of $3\frac{1}{2}$ inches, the slater will, unless especially cautioned, drill the holes $11\frac{3}{4}$ inches from the tail, leaving $8\frac{1}{4}$ inches from the holes to the head; this, the slaters say, gives a lap of $3\frac{1}{2}$ inches, and a glance at the shaded slate and the dimensions in fig. 83 might seem to bear out their view. Two little details, however, are ignored by the slater, the *first* being that slates vary a little in size, and the *second* that nails must be entirely *above* the head of the slate below, and not exactly on the line of the head. These two little details are really of great importance, for, in order to make sure that the nails in one course will be quite clear of the heads of the *longest* slates in the course below, the slater allows from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch from the head of the average slate to the holes in the slate above. I have known 20-inch slates holed as described, and yet laid with a lap of less than 2 inches, a lap quite insufficient to render a low-pitched roof water-tight in an exposed situation, unless the slates are laid on boards and felt. Slates should therefore always be holed to show at least one inch more lap than is specified. The distance of the nail-holes from the tail of the slate may be found by the following simple rule, the several dimensions being stated in inches:—

$$\frac{\text{Length of slate} + \text{lap} + 1}{2} = \text{distance of nail-holes from tail.}$$

Slates are laid either **on battens or on boarding**; sometimes on battens nailed to boarding. For common work, battens alone (or, as they are often called, "laths") are used, as they are least costly. The laths are nailed to the rafters, and if these are not more than 12 or 13 inches *apart*, the laths need not be more than about $1\frac{1}{2}$ inch × $\frac{3}{4}$ inch or $1\frac{3}{4}$ inch × $\frac{7}{8}$ inch. The laths must be spaced according to the size of the slates and the required lap:—

$$\frac{\text{Length of slates} - \text{lap}}{2} = \text{distance of laths from centre to centre.}$$

Thus, for slates 20 inches long, specified to be laid to a lap of $3\frac{1}{2}$ inches, the distance from centre to centre of the laths must be

$$\frac{20 - 3\frac{1}{2}}{2} = 8\frac{1}{4} \text{ inches.}$$

Slates laid on laths must be pointed or torched underneath with haired mortar.

The house, however, will be drier and of more uniform temperature if **boarding covered with felt or waterproof paper** be used instead of laths. The boards may be $\frac{3}{4}$ or 1 inch thick, tongued and grooved to prevent warping, and nailed to the rafters either horizontally or diagonally. As snow and rain will drive through the joints of the slates, it is necessary to cover the boards with some impervious material which will protect them from the moisture and from consequent decay. The material may be either *Willesden waterproof paper* (one-ply or two-ply), or some kind of *felt*. Felt is more frequently used. Of this material there are two principal varieties—*tarred* felts (which are usually known as "sarking" or "roofing" felts), and felts prepared with resin instead of tar, and known as "*inodorous*" felts. The tarred felts are tougher and more durable, and less liable to injury by vermin, and the smell is scarcely perceptible when the roof is complete. The thicker qualities of each kind should be selected. Felt is supplied in rolls usually 32 inches wide, and is laid in horizontal courses, each new course overlapping that below it about 1½ or 2 inches, all being secured to the boarding with nails.

Sometimes the slates are nailed directly to the sheathing, or to horizontal **laths** nailed to it, but a better plan consists in nailing thereon laths or battens running from eaves to ridge either directly or diagonally, and in nailing to these the usual horizontal slating laths. The space thus formed between the sheathing and the slates keeps the roof warmer, and helps to preserve the wood and slates from decay. The slater proceeds by nailing a **tilting-fillet** along the eaves, as shown at D in figs. 78 and 79. This is necessary, in order to give the slates that slight variation from the slope of the roof which is required to allow them to bed close to each other throughout their length. If the tilting-screed or its equivalent were omitted, the tail of each slate would stand clear of the slate below, and the wind and rain would find entrance, and might, indeed, strip off the slates.

The first course of slates must be shorter than the ordinary slates by the amount of the **gauge** to which the slating is to be laid. The gauge of slating as of tiling is the length of slate (or tile) exposed to view in each course. For 20-inch slates laid to a lap of 3½ inches, the gauge, as shown in fig. 79, is 8¼ inches. The subsequent courses need no explanation.

All slates must be secured with **nails,** which may be 1½ or 2 inches long, according to the thickness of the slates, and may be of copper, zinc, or "composition" (a mixture of copper, zinc, and tin). Iron nails, whether galvanized or not, should not be allowed, as they soon rust. Copper nails are used for the best work, but composition nails are also durable.

Roofing-tiles are of several kinds, the most generally used being the "plain" (or "plane") tile, similar to those described in Chapter III. of this Section, pp. 109–110. These are either simple oblongs or shaped on the lower edge, and are hung to wood laths by nibs formed on the tiles, or (in exposed situations) by copper or galvanized iron nails about 2¾ inches long. The usual colour is deep red, but other colours can be obtained—strawberry, blue, brindled, &c.—and semi-vitrified or glazed tiles are also made, and have the advantages of durability and imperviousness. Hips and valleys are formed by special tiles, as shown in fig. 84, and wide tiles are inserted in the alternate courses of gables in order that the tiles may break joint. Roof-tiles are laid to gauges of 4, 3½, or 3 inches, 54, 62, and 72 tiles respectively being required in every square yard. Tiles are heavier than slates, and as a rule more absorbent and more expensive; on the other hand, they are warmer. The Ruabon and Broseley tiles enjoy a good reputation.

A novel method of laying plain tiles on concrete or mortar, instead of on boards and felt, was introduced some years ago by Mr. Ralph Nevill, and has stood the test of experience. The first operation consists in nailing the plaster-laths to the underside of the common rafters, lest, if it were done afterwards, the concrete might suffer by the jarring. Single fir laths are then fixed with lath-hooks to the upper side of the rafters, and an eaves-lath or tilting-fillet is nailed

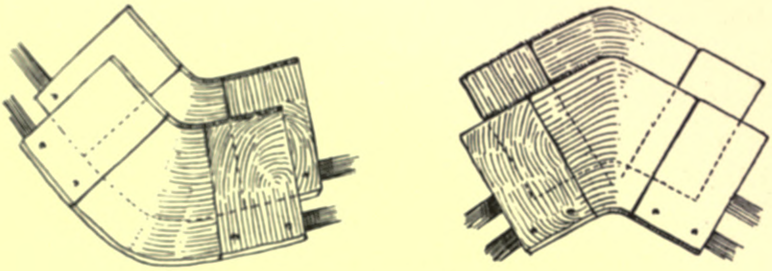


Fig. 84.—Hip-tiles and Valley-tiles.

along the eaves. Copper nails $2\frac{1}{2}$ inches long are then driven into the upper side of the rafters at distances of about 4 inches, and left projecting about an inch to furnish a key for the concrete, which is subsequently deposited to a thickness of about $1\frac{1}{4}$ inch. This concrete consists of *one* part of clean sharp sand, *three* parts of finely-sifted clean ashes or coke-breeze, and *one* part of a mixture of selenitic lime and Portland cement (3 to 1). The concrete must be laid in long strips, beginning at the eaves, and laying only so much as can be covered with tiles before it has become too hard. The surface must be trowelled fairly smooth, particular care being paid to the hips and valleys. After the concrete has been deposited for about 6 or 8 hours in the daytime, or about 10 or 12 at night, it will be ready to receive the tiles. The tiles may be gauged by means of chalk lines snapt on the concrete, and are fixed by pressing two pins to each tile into the still moist concrete; "the thickness of concrete against chimneys, barge-boards, &c., should be slightly increased, so as to tilt the tiling; and throw off the water. As there will be no foothold on the roof, and all the tiles will be worked over, it will be necessary to sling a cradle over the ridge, resting on well-stuffed bags. To avoid returning over the tiles, it is important that the ridge should be fixed as the tiling is done."[1]

Of **special roofing-tiles** there are numerous varieties. Pan-tiles are only

[1] *The Builder*, Dec. 9' 1896.

used for farm-buildings and cheap work, but several other varieties are suitable for good houses, such as the Broomhall tile, Major's, Taylor's, and others. Concrete roof-tiles have also been made, and a special diamond-shaped sort is now being introduced into this country after having achieved some measure of success abroad; its appearance, however, is most inartistic.

"**Ridging**" is the name given to the materials used for covering the ridges of roofs. Blue and red ridge-tiles are now most generally used on account of their cheapness, but stone and slate ridging are also used; these should all be bedded and jointed with cement-mortar. Wood rolls covered with lead or zinc must also be mentioned. Fig. 85 shows a $2\frac{1}{2}$-inch wood roll with $1\frac{1}{2}$-inch neck, and a sheet of lead 24 inches wide dressed over the roll and down the slates about 7 inches on each side, and nailed to the wood roll with round-headed nails. The neck allows the lead to be dressed a little under the roll, and so be securely held to it. The end joints between two sheets of lead are simple laps of about 6 inches.

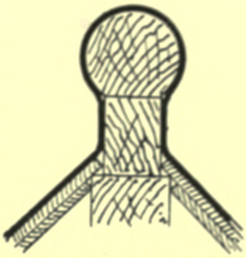


Fig. 85.—Ridging formed with Wood Roll and Lead.

Hips may be formed in tiled roofs by special tiles as already explained, and in slated roofs by ʌ-shaped tiles or other material, or by wood rolls and lead, exactly as ridges. Frequently, however, the hips of slated roofs are formed by carefully cutting the slates to the requisite angle (known as "close bevel cutting"), and inserting at the angle in each course of slates a thin lead soaker ($2\frac{1}{2}$ or 3 lbs. per sq. foot) cut to the proper shape and bent to the angle of the hip; this is the neatest method of forming hips.

Valleys in slated roofs are formed with 5 lbs. or 6 lbs. sheet-lead, about 18 inches wide, laid (with laps of from 3 to 6 inches at all joints) on boarding. In tiled roofs, curved valley-tiles may be used.

The **dead weight of roofs** varies considerably, but the table on p. 148 is approximately correct.

Eaves-troughs or **gutters** are still sometimes made of wood, but as a rule cast-iron is now preferred. Lighter gutters of galvanized wrought-iron and of zinc are also made, but are not as durable as cast-iron. Eaves-troughs should be securely fixed, either by being screwed to a fascia nailed to the end of the rafters, or by wrought-iron hangers nailed to the upper side of the rafters or boarding, and passing under the trough. Hangers are sometimes of ornamental appearance. In addition to screws or hangers, the gutters may be supported on stonework or on iron brackets. Stone cornices are sometimes hollowed and lined with lead to form eaves-gutters.

TABLE V.

WEIGHT OF ROOFS.

Material.	Weight per sq. yd. in cwt.
Timber framing, ...	·3 to ·5
Boarding 1-inch thick,...	·2 „ ·25
Copper,...	·1 „ ·12
Zinc, ...	·12 „ ·14
Lead, ...	·6 „ ·7
Welsh slates, ...	·6 „ ·9
Westmoreland slates, ...	·8 „ 1·2
Plain tiles, ...	1·2 „ 1·6
Concrete and asphalt, ...	4 „ 6

Instead of lead gutters, like those shown in figs. 76, 79, and 81, **cast-iron gutters** of the requisite section and $\frac{1}{4}$, $\frac{3}{8}$, or $\frac{1}{2}$ inch thick, are sometimes used. The joints may be either lap-joints, or butt-joints with flanges bolted together; the joints must be carefully made with a mixture of red and white lead, or with a mixture of iron-borings, sulphur, and sal-ammoniac. Iron gutters of this kind condense moisture, and are somewhat apt to leak (for a time at least), besides being damaged by rusting. In certain circumstances, however, they can be used with advantage.

In this connection a few words may be said about **rain-water pipes.** They are now seldom made of wood, although here and there a prejudice lingers in favour of this material. Most frequently cast-iron pipes are used; they are made circular and rectangular, the former being the stronger and more durable. Rain-water pipes should be fixed so as to stand about 2 inches from the wall in order that they can be painted all round, and that in case of a leak the wall will not be saturated with the water. This object may be effected by wood blocks, or (better) by using a special pipe such as Law's, or the Perfection, as shown at P in Plate III. Solid-drawn lead pipes have recently come into use. They are expensive and easily bulged, but on the other hand they do not need painting, and do not crack as easily as iron pipes; nor do they rust. The thickness of the metal should be from $\frac{3}{32}$ to $\frac{1}{8}$ of an inch, *i.e.* from 6 to 8 lbs. per sq. foot, and the pipes must be secured to the walls by lead tacks not more than 3 feet 6 inches apart. It is a mistake to use small rain-water pipes; the smallest size allowable is 2 inches in diameter, and this should only be fixed to the roofs of bay-windows and other minor roofs. Pipes 3, $3\frac{1}{2}$, and 4 inches in diameter are better.

Rain-water pipes should not on any account be connected directly with the sewage-drains, but should discharge over or into trapped gullies. The position of rain-water pipes should be so arranged that they help to flush the drains; *e.g.* a rain-water pipe near a sink-waste or a soil-pipe greatly assists in keeping the drains clean. They may also with advantage be connected with an automatic flushing-tank at the head of the principal drain.

CHAPTER VIII.

FLOORS.

1. *GROUND-FLOORS.*

Impervious ground-floors resting on the solid ground have certain advantages over the ordinary joisted and boarded floors raised a foot or so above the ground or ground-layer. They are more secure against rot, and afford no space for dirt and vermin to lodge, besides effecting, in many cases, a saving in excavation, foundations, and walls.

They may be formed of **concrete** on the top of the asphalt layer, as shown in figs. 34, 38, and 39, and in Plate II. This concrete need not be more than 1½ or 2 inches thick, save in those exceptional cases where considerable pressure of water has to be resisted. In places where appearance is no object, or where the traffic is light, the concrete may consist of one part of Portland cement and two parts of pea-gravel, well mixed and trowelled or floated to a smooth surface. The less sand that is used the better, as it renders the concrete less durable, and therefore causes more dust. For better work, hard limestone, marble, granite, syenite, spar, alabaster, glass, pottery, &c., crushed and passed through a screen with half-inch meshes, may be used instead of gravel. A mixture of these materials gives variety to the appearance of the floor, and sometimes additional variety is given by pressing somewhat larger pieces into the concrete here and there as soon as it is laid. When the cement has set properly, the floor is ground down with stone rubbers, sand, and water, until a clean polished surface is obtained. Frequently colouring matter—Venetian red, ultramarine, &c.—is added in mixing the ingredients, but a more permanent colour effect is obtained by the use of coloured aggregates, chiefly marble and granite; borders and centres are often finished in different colours. These polished concrete floors are often known as **concrete mosaic,** but the more general name now is **terrazzo.** When properly laid, they are extremely durable and clean, and have a pleasing appearance. They are suitable for corridors, pantries, &c., and also for sculleries, water-closets, bath-rooms, wash-kitchens, and other places where much water is used, but for living-rooms they have the demerit of coldness.

Concrete mosaic must not be confounded with **Roman mosaic,** each tessera of which is carefully laid by hand in the exact position required by the design. This is a more expensive kind of floor, but affords scope for ornamental effects impossible in the other. The cubes are usually of marble or fine pottery, the latter being known as *ceramic mosaic* and the former as *marble mosaic.* A bed of cement-mortar floated to a perfectly level surface must be prepared to receive the mosaic.

Tiles of various kinds are also used for floor-surfaces, and must be laid in quick-setting cement on a level bed of cement-mortar. Sometimes thin slabs of **marble,** or of other hard and ornamental stones, are laid in patterns in cement-mortar. All these floors are as a rule clean and durable, but are often noisy and slippery, and cold.

Sometimes an ordinary smooth finishing coat of cement-mortar is given to the concrete, and on it **kamptulicon, linoleum,** or **cork carpet** is glued. These add to the warmth, comfort, and quiet of the room, and are durable enough if the floor be dry. It is best to select a material of one colour throughout, as such a one is most serviceable, and as a rule most pleasing.

For living-rooms, however, a wood surface is usually preferred on account of its warmth. This can be obtained by using either **wood-block flooring,** or **parquetry.** The latter is as a rule the more ornamental and perfect flooring.

The ordinary **wood-block flooring** consists of blocks of wood from 1 to 2 or even 3 inches thick, and usually 9 inches by 3 inches on the face, grooved along the sides as shown in fig. 86, and laid in molten pitch or bituminous composition on a perfectly level and dry surface of cement-mortar or natural asphalt. The pitch should be well squeezed into the grooves of the blocks, and the whole of the floor when laid should be well planed, so as to bring all the blocks to one smooth and uniform surface. The pitch in which the blocks are embedded is itself damp-proof, but it not infrequently happens that cracks and holes are left in it, through which moisture rises to the wood, causing decay. For perfect safety the ground-layer should be covered entirely with an asphalt damp-course as already described, on which the wood-blocks may be laid in molten pitch in

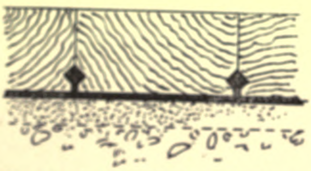


Fig. 86.—Ordinary Wood-block Floor.

the usual way. Blocks with faulty grooves, or badly laid, or of unseasoned wood (especially pitch-pine), frequently wear loose. Hence special systems of flooring have been devised, in which the blocks are firmly secured to each other or to the bed by means of tenons, dowels, screws, &c. These systems undoubtedly have their advantages, and should be adopted where the additional outlay can be afforded.

Various kinds of wood may be used for block floors, the cheapest being yellow or red deal; other woods are pitch-pine, oak, teak, walnut, jarrah, mahogany, and also beech, birch, and the dark-red Indian wood known as padouk. Red-deal blocks ought never to be less than $1\frac{1}{2}$ inch thick; sometimes blocks 2 inches and more in thickness are used. The harder woods are usually laid in blocks 1 inch or $1\frac{1}{4}$ inch thick, the thicker being the more secure and durable, and of course more expensive. The peculiar odour of teak must not be forgotten when the selection of wood is being made; the odour—or rather the oil which yields the odour—apparently renders the wood less liable to the attacks of insects, but it is to many persons objectionable, and teak cannot therefore always be adopted. Oak is the wood most largely used in good work, walnut, mahogany, &c., being occasionally introduced in bands and patterns to add to the effect.

Hardwood floors are often **wax-polished,** and sometimes **French-polished;** these processes add to the brightness of the floors, and at the same time render them cleaner, as all the joints and pores are stopped by the wax and shellac.

A variety of wood-block flooring consists of the use of longer pieces of wood, "secret-nailed" to fixing-blocks embedded in the concrete below, or to fillets of coke-breeze concrete. Special fixing-blocks for the purpose, composed of a kind of concrete capable of holding nails, can be obtained in 12-inch lengths, and of dovetailed section. Wood fixing-blocks must not be used, at any rate on ground-floors. The damp-course of asphalt (natural or artificial) must not be omitted from the ground-layer, or the wood above may rot. The joints of the boards may be as shown in fig. 87, where joint No. 3 is that used in the patent "Pavodilos" flooring. These boards may be polished as ordinary block floors.

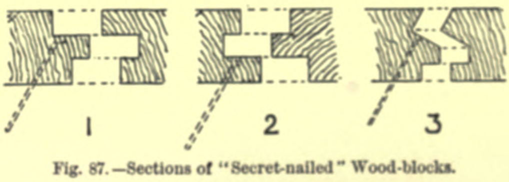


Fig. 87.—Sections of "Secret-nailed" Wood-blocks.

Parquetry is the most elaborate and the most sanitary kind of wood flooring. It consists of small pieces of hardwoods of various kinds and colours, arranged in patterns (often of considerable intricacy), and carefully dowelled, glued, and screwed together. Sometimes the parquetry is one inch thick, each piece of wood being the full thickness; it is then known as "solid" parquetry. "Plated" parquetry consists of a hardwood surface about ¼ inch thick, fixed to a properly-framed deal backing, or, as in Turpin's patent, to two or three thin laminations or layers of hardwood well glued together; in Mackenzie's system a metal backing is used. Panels of plated parquetry, containing about 100 square feet, can be supplied by the makers ready for fixing. Parquetry, like wood blocks, must not be laid on ground-layers unless an asphalt damp-course has been spread to receive it. Flagged floors may be covered with asphalt and finished with parquetry ¼ inch thick. The surface of parquetry may be wax-polished or French-polished, the latter process being a little more expensive.

Floors resting on the solid ground were at one time formed chiefly with **flags, tile quarries, or bricks,** without any preparation beneath except a layer of ashes. This method of construction is seldom adopted now in towns, as it is cold and damp, and, indeed, in most cases it would be in contravention of the by-laws. A layer of concrete 6 inches in thickness is usually demanded, and this, in the case of tiles and bricks, should be floated level with cement-mortar (1 to 2). The joints of flags, tiles, and bricks should be run with neat cement-grout.

Hitherto we have been dealing with floors resting on the solid ground or on the concrete ground-layer. Frequently, however, floors constructed of **wood joists and boards** are desired for ground-floor rooms; sections of such floors have already been given on pages 72 and 80, and in Plate III. The ends of the joists should not be built into the walls, but should rest on wall-plates laid on set-offs formed in the walls, and should always be above the damp-course. Sleeper-walls are often built at intervals under such floors in order to lessen the bearing of the joists, and consequently their scantling, but such walls are of doubtful advantage in most cases, as they interfere with the circulation of air under the floor, and may therefore induce decay in the wood. The boards are usually 1 or 1¼ inch thick, and tongued and grooved at the edges to prevent warping, and to guard against crevices extending through the full thickness of the boards in case of shrinkage. Good yellow (or as it is often called, "red") deal is the best wood for both joists and boards, but white deal and spruce are often used in cheaper buildings. The rings in red deal should be clearly marked and of bright colour, and the wood should be free from sap, cracks, large knots, and especially from any trace of fungus or decay. For buildings of the best class, and especially for ball-rooms, oak (or other hardwood) boards are used, either alone or on the top of deal boards, and may be left in the natural state or polished at will.

Dry rot is the great danger to be feared in wood ground-floors. This is a kind of decay caused by the development of a fungus, the *Merulius lacrymans*, four conditions favouring the growth, namely—stagnant air, dampness, warmth, and absence of light or sunshine. The first two conditions are those with which the architect is most concerned, and these he can generally avoid by adequate ventilation and by impervious ground-layers and walls. The ventilation, however, must be adequate; particularly must every corner of the room have its own ventilator. It is not sufficient if air-grates or ventilating damp-courses are inserted on one side only of a room, or on two sides at right angles to each other; ventilation must be ensured on at least two sides opposite to each other, so that a through current of air may be induced. To secure this, it will often be necessary to form air-drains with bricks or drain-pipes under adjacent solid floors, or to construct vertical air-flues in the walls, gathered perhaps to the smoke-flues above. The air-grates below the floor-level must be carefully protected outside, so that they may not be inadvertently blocked. Many cases of dry rot have been developed in consequence of gardeners having covered the air-grates which the architect had carefully provided. Care must be taken in selecting the wood for floors, as in many cases traces of white fungoid growth can be seen before the wood is fixed; a consignment containing wood of this sort should be condemned in bulk. Chips of wood left under floors are a source of danger, and impervious floor-coverings, such as linoleum, by preventing the passage of air, increase the risk of rot.

Wet rot is not as insidious or as frequent as dry rot, and the quantity of moisture necessary for its appearance will never be present in a building carried out with reasonable care and skill.

2. *UPPER FLOORS.*

The upper floors of ordinary houses are usually formed with **wood joists covered above with floor-boards** and beneath with wood laths and plaster. The joists must be trimmed (see fig. 70, page 130) around all fireplaces, and for stair-wells and other openings. It is better for the ends of the joists to rest on set-offs formed in the walls, as shown at A in Fig. 48, page 107, but where this cannot be done the joists must touch the walls only on their lower surfaces, so that a clear space is left around the ends for circulation of air. This reduces the risk of rot. Special joist-boxes of cast-iron or stoneware can be obtained for building into walls to receive the ends of joists, and are more to be depended upon than a method which leaves so much to the skill and care of the bricklayer.

Sometimes in order to deaden the sound, a counter-floor is formed between the joists with rough boards nailed to fillets which have previously been nailed to the sides of the joists; the space above the counter-floor is then filled with sawdust or lime-pugging (both dangerous in respect of rot), or with silicate-cotton. Sometimes silicate-cotton slabs are nailed under the joists and fillets nailed below, to which the lath-and-plaster ceiling is attached in the ordinary way; or silicate-cotton slabs, plastered on one side and strengthened by wire-netting embedded in the mass, are screwed to the joists to form the rough ceiling. Plate III. shows a floor with ceiling-joists spiked under the floor-joists at right angles to them, thus allowing continuous circulation of air between the timbers; this space affords a simple, although not very cleanly, method of ventilating the room below, if openings are formed in the ceiling and air-grates built into the external walls.

Fig. 88.—Wood Floor and Counterfloor with Lath-and-plaster Ceiling.

Wood floors, however, of the kinds described are undoubtedly combustible, besides containing numerous inaccessible places for the accumulation of fine dust and vermin. They may with advantage be superseded by **solid wood floors,** formed with ordinary floor-joists fixed close together and spiked to each other, and either planed level on the top or covered with thin floor-boards. Such a floor is practically fire-proof, and has most of the advantages of ordinary wood floors without the disadvantages; there is, however, considerable danger of decay unless the wood is of good quality and properly seasoned.

Parquet flooring is frequently laid on the top of ordinary wood floors, and may be either fixed or removable. Thin oak boards are also used, secret-nailed as a rule, and generally polished.

Fire-resisting floors of many kinds have been largely used in recent years, but chiefly in business-premises and public buildings. In houses, somewhat strange to say, the attention has not been given to the subject which its importance warrants. As I have already pointed out, fire-resisting construction is a matter of *materials* and also of their *arrangement.* If we avoid combustible materials, such as wood, a step has been taken in the right direction, but care must also be exercised that the incombustible materials used in their stead are at least moderately fire-resisting. Undoubtedly good clay, burnt at a high temperature (whether in the form of bricks or terra-cotta), furnishes one of the best fire-resisting materials. Concrete, composed of one part of Portland cement and not more than four parts of a *suitable* aggregate (such as broken bricks, properly-burnt clay, and coke-breeze), is of considerable merit, but bad concrete, especially with stone aggregates, is most treacherous in a fire, and may collapse entirely at an early stage. Iron and steel also, although not combustible, are not by any means fire-*proof*, but bend and twist under great heat, and, if not protected, may give way and so lead to the destruction of the building.

From the facts just stated, two rules may be laid down for guidance in designing fire-resisting floors:—

1. Concrete alone is dangerous, and must therefore be protected, or prevented from total or extensive collapse.

2. Iron and steel must be entirely surrounded by an adequate thickness of fire-proof material, or in some other way protected from the action of fire.

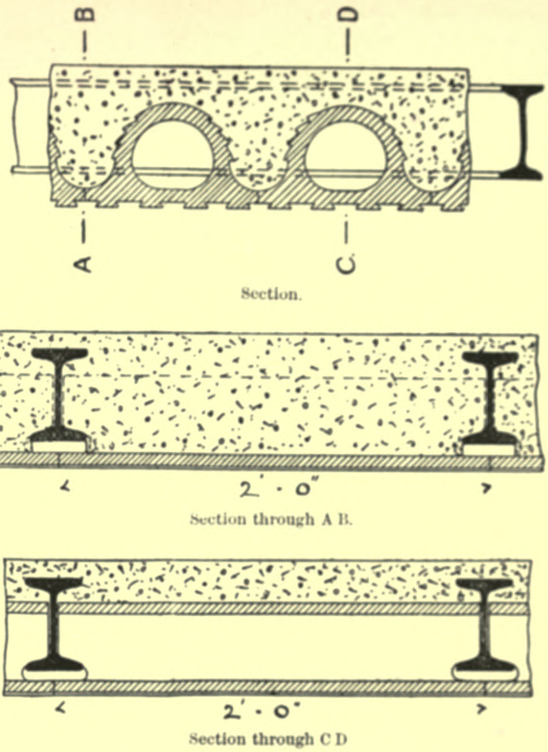


Fig. 89.—Fawcett's Fire-proof Floor.

Rule 1 throws out of court the large-span floors of concrete alone, but not concrete floors containing iron or steel joists or tees at short distances, or a meshwork of rods or bars or expanded metal, with the metal protected beneath and above by fine concrete, plaster, &c.

Rule 2, however, is more stringent, and demands greater protection of the metal from fire than is attained in ordinary fire-resisting floors. Several patented floors, however, have been designed in accordance with it. In **Fawcett's floor,** illustrated in fig. 89, the protection of the metal is obtained by means of terra-cotta tubular lintels, the ends of which are grooved to clip the flanges of the joists in such a manner that the joists are entirely protected beneath by the flat bottoms of the lintels; they are protected above by coke-breeze conerete, of which the bulk of the floor is formed. The lintels are grooved beneath to afford a good key for plaster, this furnishing an additional protection to the metal. It will be noticed that a continuous circulation of air can be maintained through the lintels and beneath the joists. The joists are of steel, fixed 2 feet from centre to centre.

Willis & Astley's and Picking's floors are of a somewhat similar kind, although perhaps a little more complex.

In **Banks's floor** the metal is protected simply by an air-space, and a fire-resisting ceiling consisting of "helical" metal lathing and plaster. It is

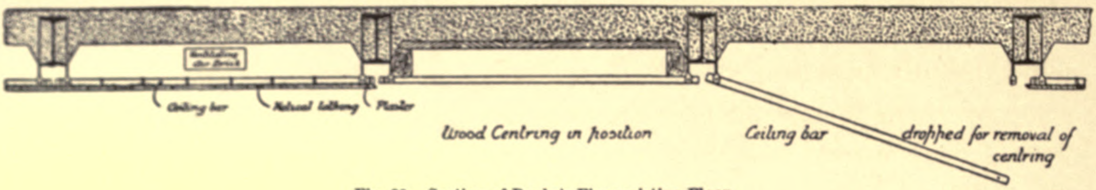


Fig. 90.—Section of Banks's Fire-resisting Floor.

illustrated in fig. 90, and has the merits of simplicity and economy, while it also affords opportunity for ventilation and is not as noisy as a solid floor.

In many upper rooms, where much water is used,—as in bath-rooms, cistern-rooms, water-closets, housemaids' closets, lavatories, &c.,—a floor of other material than wood is desirable, not so much for its fire-resisting qualities as for its imperviousness and freedom from decay. In such cases, a **simple slab of concrete** may be used for spans up to about 8 or 10 feet. Thinner floors of good concrete are more trustworthy than thick floors of inferior concrete; it is therefore better to use concrete composed of *one* part cement and not more than *three* parts of some hard aggregate (say granite or syenite), broken to pass through a screen with meshes 1¼ inch square. A thickness of 4 inches I have found to be sufficient for spans up to 6 feet, and 6 inches will suffice for 10-feet spans. For work executed by unskilled men in the ordinary way, a considerable margin of safety must always be allowed, but when the floors are constructed by specialists, the thickness may safely be reduced; flat granolithic floors have been constructed 16 feet by 9 feet, and only 3 inches thick, while arched floors of the same material, 21 feet 6 inches span and 29¼ inches thick at the springing and 3 inches thick at the crown (the rise of the arch being only 26¼ inches), are said to have been loaded with 8 cwts. per square foot without injury.

Combined **steel and concrete floors** are now largely used, the steel being in the form of expanded metal, rods, bars, tees, or joists. I have used the steel in the form of a meshwork, interlacing bars and rods, for spans up to 14 feet, but the extra labour required in fixing this probably counterbalances any saving which is effected in the quantity of metal. In America, square twisted rods are often employed, the twist preventing the rods being drawn through the concrete when subjected to the usual stress. Steel tees, flat side down, may be used with economy to increase the strength of concrete floors. When the metal is in the form of tension members only, it is particularly important that the wood staging should be perfectly rigid; otherwise it will sag under the weight of the wet concrete. As a general rule, however, the metal in concrete floors is in the form of joists, fixed from 2 to 4 feet apart, and varying in size according to the spacing, the span, and the load. Joists strong enough to bear the weight of the concrete and of the load on the floor, are generally used; this is somewhat wasteful of metal, but the resulting floor will generally, notwithstanding this, be cheaper than any of the special floors,—cheaper even than a floor of granolithic concrete alone. Such at least is my own experience. The following table gives the sizes and weights of steel joists which may be used in floors of this description in houses, the joists being fixed 2 feet from centre to centre.

TABLE VI.

STEEL JOISTS IN CONCRETE FLOORS.

Size of Joists.	Weight per ft.	Maximum Span.
in. in.	lbs.	feet.
$3\frac{1}{2} \times 1\frac{1}{2}$	6	8
$4 \times 1\frac{3}{4}$	8	10
4×3	$9\frac{1}{2}$	12
$4\frac{3}{4} \times 1\frac{3}{4}$	10	12
$5\frac{1}{2} \times 2$	$10\frac{1}{2}$	13
5×3	11	14
6×3	13	16

The wood staging for concrete floors should be fixed at least half an inch below the steel joists, and the space between the boarding and the joists should be thoroughly filled with cement-mortar (1 to 2) immediately before the concrete is deposited. The staging should remain in position as long as possible; where joists are not used, the period should be not less than six weeks. Concrete floors are strongest when laid over the walls and subsequently built upon, but where this cannot be done, corbel-courses or chases must be formed to receive them. Newly-deposited concrete must be protected from traffic, drought, and frost. Coke-breeze is a common aggregate for floor-concrete, on account of its lightness; it is, however, weak, and may with advantage be superseded by broken brick.

The surfaces of concrete upper floors may be finished in one of the ways described in the former part of this chapter, or with wood fillets to which ordinary floor-boards are nailed. Sometimes coke-breeze fillets or composition blocks are used to receive the boarding, as wood fillets are somewhat apt to decay.

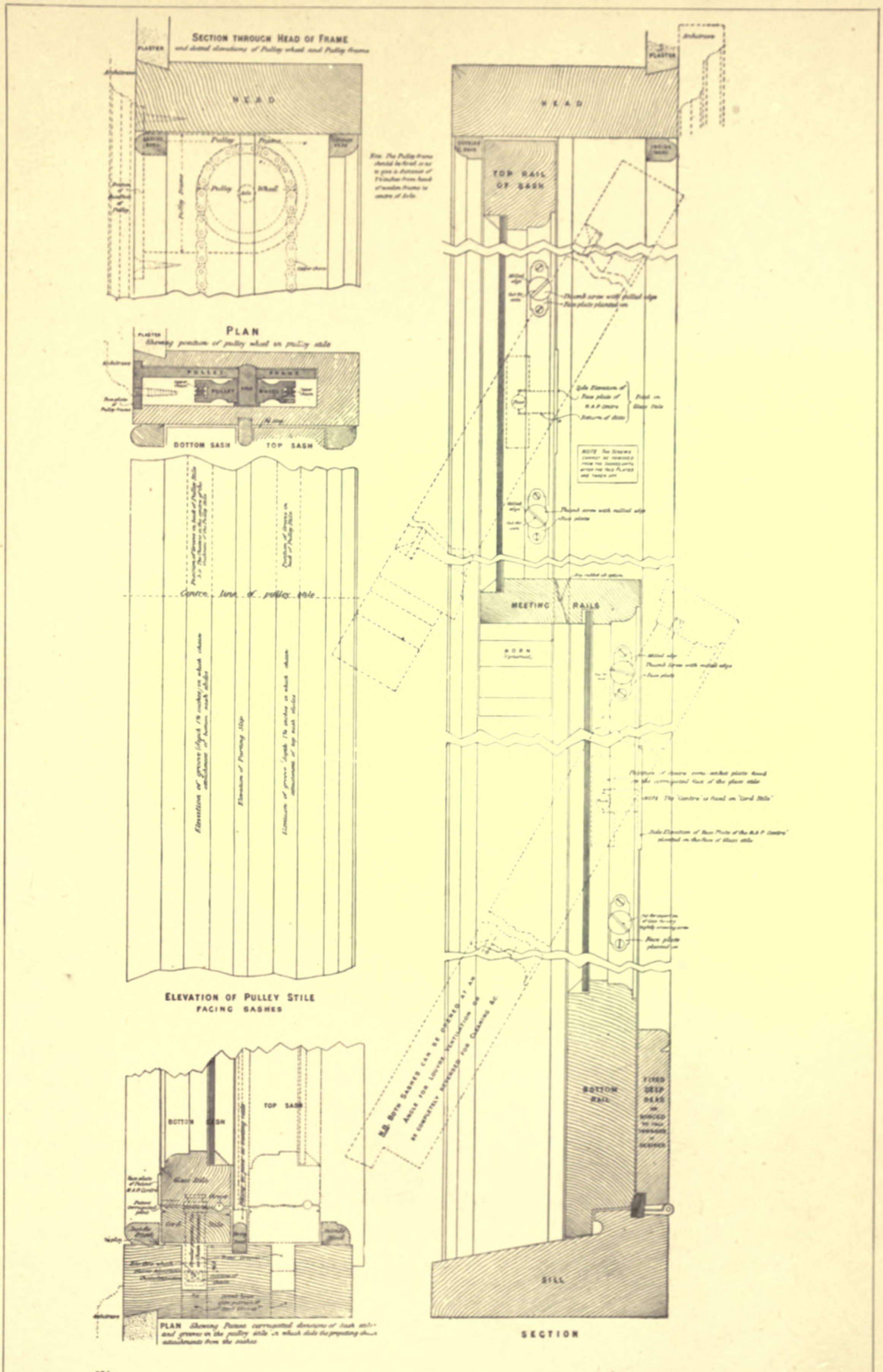
CHAPTER IX.

WINDOWS, DOORS, SKIRTINGS, AND STAIRS.

1. *WINDOWS.*

The **windows** of a house have a very important influence on its comfort and healthfulness. To some of the general principles of window design, attention has already been drawn in Chapter I. A few words must now be said on the practical details of their construction. The insertion of glass into grooves in the stonework of windows is now nearly obsolete, and deservedly so, on account of the lack of ventilation, and the number of cracked sheets of glass caused by the rigid framework, and the trouble of replacing them. It is usual nowadays to provide a wood or metal frame to receive the glass. Windows are of two principal classes, *sash-windows* and *casements*, and each class has its peculiar advantages and disadvantages.

Sash-windows are peculiarly British in their origin and development, being seldom seen abroad. They are especially suitable for openings of considerable size, but look clumsy when used in small mullioned windows. They are convenient, easily made weather-proof (although somewhat apt to rattle in strong wind), and may be readily used for ventilation. On the other hand, they are somewhat intricate and apt to get out of order, and the outside of the glass is difficult to clean. Indeed so great is the trouble of cleaning, and so many accidents have occurred to persons standing on the window-sills for this purpose, that it is no wonder that inventors have turned their attention to the subject. Numerous patents have been taken out for windows so arranged that the sashes can be reversed, and therefore cleaned from the inside of the room. In Glasgow, the building-regulations require all new sashes to be reversible, and other towns will doubtless follow the example before long. Reversible sashes may be hung in the ordinary way with cords and weights, or may be hung over pulleys so as to balance each other, thus dispensing with weights. Details of the National Accident Prevention Company's "weightless" window are given in Plate IV. In such windows the bottom sash necessarily rises when the top sash is lowered, and as it is frequently desirable that air should be admitted to the room only at the meeting-rails and top of the window, it becomes necessary to give a very deep bottom rail to the bottom sash and to fix a correspondingly deep face-board inside, as shown in the section. A similar arrangement is, however, advantageous in ordinary sashes, as air can then be admitted at the



THE N.A.P. WEIGHTLESS REVERSIBLE WINDOW.

meeting-rails only when desired, where it acquires an upward current; the risk of draughts is thereby reduced.

Into the details of ordinary sash-windows it is not necessary to enter. One or two points, however, may be mentioned. The sills should be of oak or teak, and weathered and throated on the top; in the section in Plate IV. only one throating is shown, but another, immediately under the outer face of the bottom rail, is often formed, as in Plate V. The sills should be bedded in white-lead, and the joint is all the more weather-tight if a galvanized iron weather-tongue (about 1 inch by ¼ inch) is let into grooves cut in the under side of the wood sill and the upper side of the stone sill, and bedded in white-lead. The meeting-rails should be rebated at their junction, one method being shown in the illustration. If the vertical parting-beads between the sashes are of teak, there will be less likelihood of them swelling and of the sashes sticking fast. Red (yellow) deal is the wood most frequently used for the sashes themselves and the other parts of the frames, but in high-class buildings oak, mahogany, and other woods are preferred. Weights may be of iron or lead, the latter being more expensive but less bulky. Sash-lines may be of hemp, flax, steel ribbon, or zinc, copper, or steel chains; hemp is coarse and cheap; superfine flax is a very good material, but for heavy sashes the steel and copper lines are the best. Cheap pulleys are wholly of iron; better ones are brass-bushed, while the most expensive have also brass faces and brass wheels. Sash-fasteners are of infinite variety, the simple screw-fastener being as safe as any, and having the merit of drawing the sashes tightly together and preventing rattling to some extent.

A combined sash-and-casement window is illustrated in Plate V. This is simple and weather-proof, and allows the glass to be cleaned inside the room. It is little more expensive than an ordinary sash-window, and combines with it the merits of a French casement. In the illustration the lower sash is much larger than the upper, and consists really of two casements hung to stiles to which the weights are attached, and which slide up and down in the ordinary grooves. The upper sash is simply an ordinary sliding sash; this can, however, be fitted with folding casements if desired. The fittings required for a combined window of this kind are somewhat numerous. Besides the usual pulleys, lines, and weights, there ought to be a bolt at the foot of each casement and a sash-fastener at the top; sunk handles for raising the lower sash may with advantage be fixed in the bottom rail, and a loop in the top rail of the upper sash for lowering this by means of a stick and hook. A short but strong bolt to unite the meeting-stiles of the casements allows the two casements to be raised together, but the same object may be attained by carrying a rail across the head of the casements. The latter method, however, is somewhat clumsy, the window becoming practically an ordinary sash-window with casements hung in the sashes.

Casement-windows are almost universal on the Continent. Indeed, large casement-windows reaching to the floor are commonly known as "French windows". They are, however, now frequently used in this country, being better adapted than sash-windows for the small mullioned windows now in vogue. They consist of a casement hung (generally with butt hinges) in a fixed solid frame. The casement may open inward, which has the merit of allowing the glass to be easily cleaned on both sides, but adds to the risk of rain being driven into the room and of the window being blown open, and interferes with the blinds and curtains; or it may open outward, when these conditions will be reversed. Fig. 91 shows the jamb and sill of an inward-opening wood casement, and fig. 92 those of one opening outward. The sills should be of oak, weathered and throated, and provided with a weather-tongue. "French casements" are usually hung folding, and the meeting-stiles may be shaped in a great many ways; a good water-tight arrangement is given in fig. 93, and another was given in Plate V. Fig. 94 contains details (one-fourth full size) of the N.A.P. wood casement, which is so designed that it will open either inward or outward on a double-knuckle hinge shown at C. Special precautions are taken to prevent the

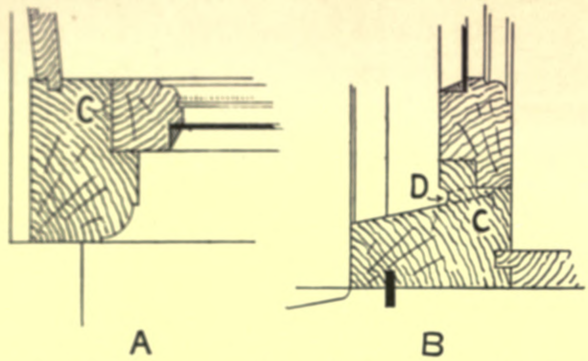


Fig. 91.—Wood Casement and Frame, the casement to open inward.

A, horizontal section of jamb and stile; B, vertical section of sill and bottom rail; CC, grooves to collect water driven along joints between casement and frame; D, holes to convey water from grooves to sill outside.

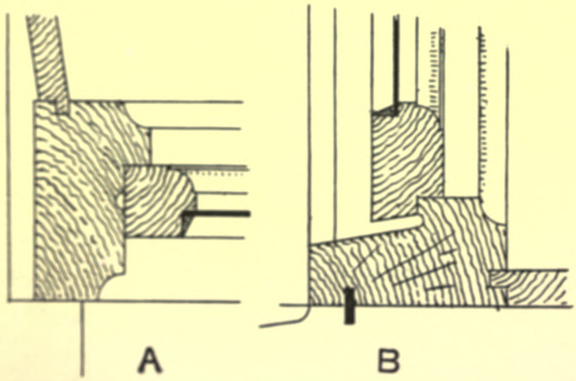
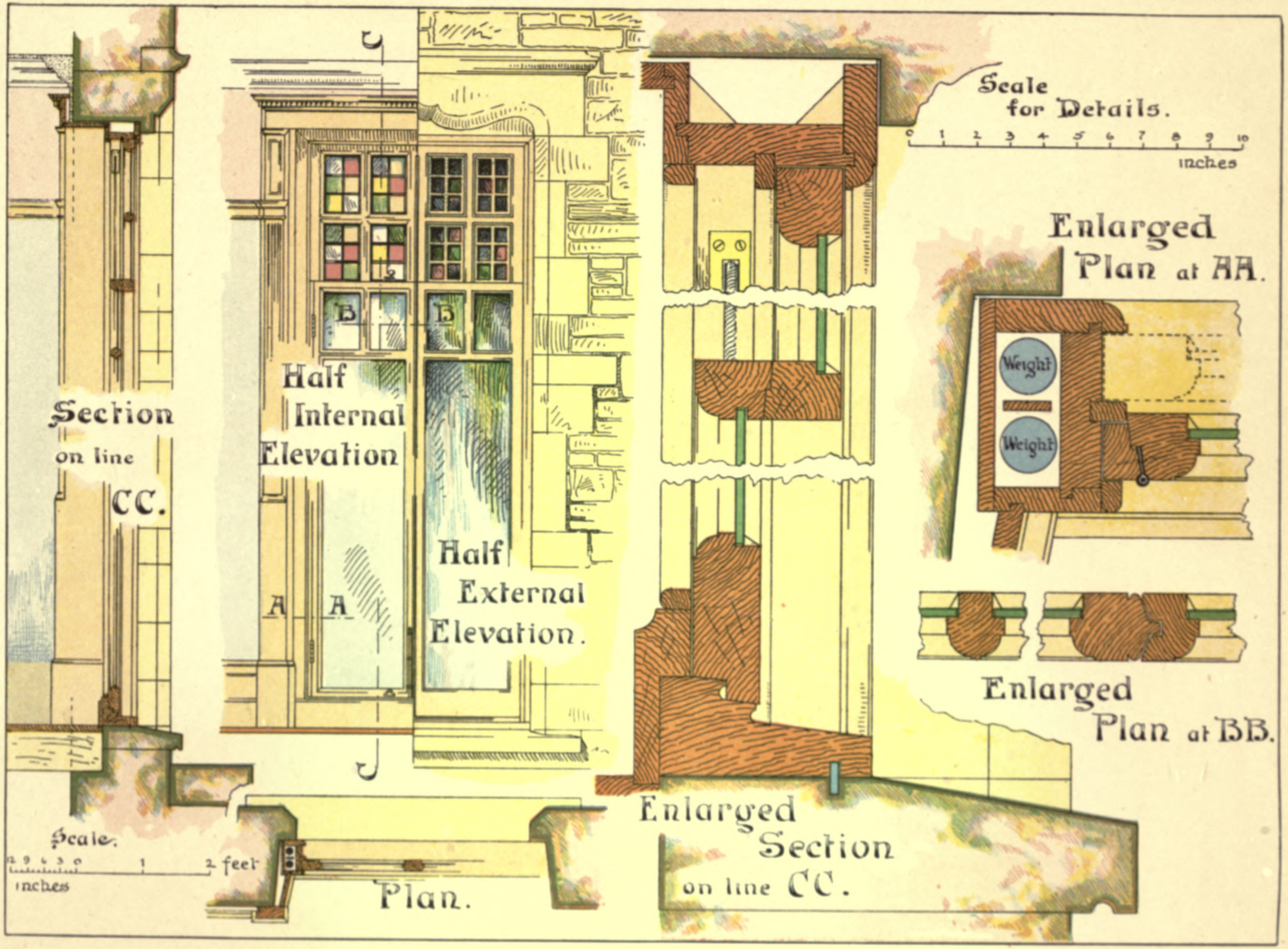


Fig. 92.—Wood Casement and Frame, the casement to open outward.

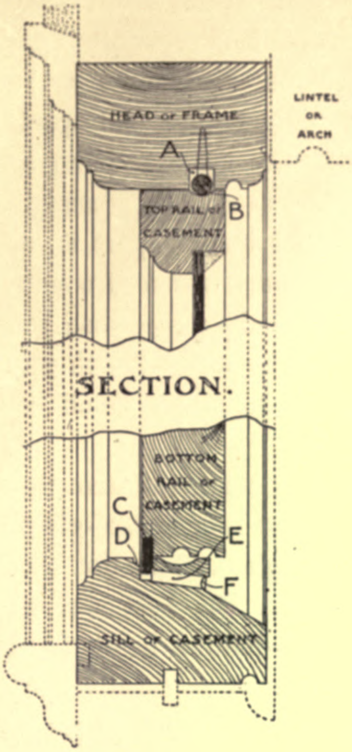
A, horizontal section of jamb and stile; B, vertical section of sill and bottom rail.

Fig. 93.—Meeting-stiles of French Casement.



DETAILS OF COMBINED SASH-AND-CASEMENT WINDOW.

ingress of rain; these are clearly explained by the drawings. The purpose of the invention is to facilitate the cleansing of the glass, while at the same time



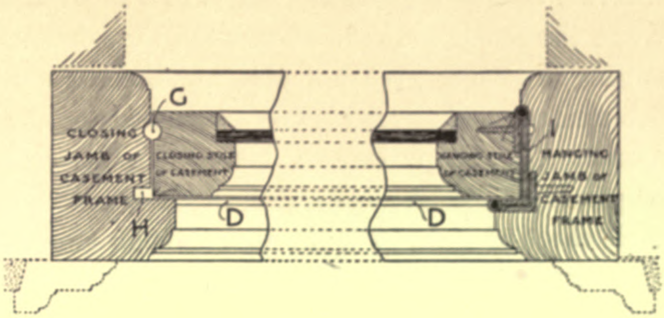


Fig. 94.—The N.A.P. Window Casement, inward and outward opening. (One-fourth of full size.)

A, groove to receive brass weather-rod; B, brass rod, which automatically rises from the position shown (travelling up the necks of two screws), as the casement is swung either inwards or outwards; C, position of water-bar when the casement is in ordinary use; D, condensation-channel; E, two outlets (from D) at ⅓ the width of casement; F, outlet (from weather-channel on top of sill) in centre of casement; G, throat to receive rain-water, but single or double rebates may be substituted if desired; H, groove (for a height equal to the width of the casement) to receive the water-bar when in the vertical position which it occupies while the casement is passed through the frame; I, patent N.A.P. double-knuckle hinge.

retaining some of the advantages of the outward-opening casement.

Metal casements are now frequently used, wrought-iron being most common but gun-metal being adopted in the very best work. They can be obtained in a great variety of sections, from simple L-iron to complicated arrangements like that shown in fig. 95. The sill, jambs, and head of the opening must be specially prepared to suit the section of casement-frame which may be adopted. Metal casements are expensive, but they do not take up much room, and they are durable if regularly painted. Gun-metal, of course, does not require painting.

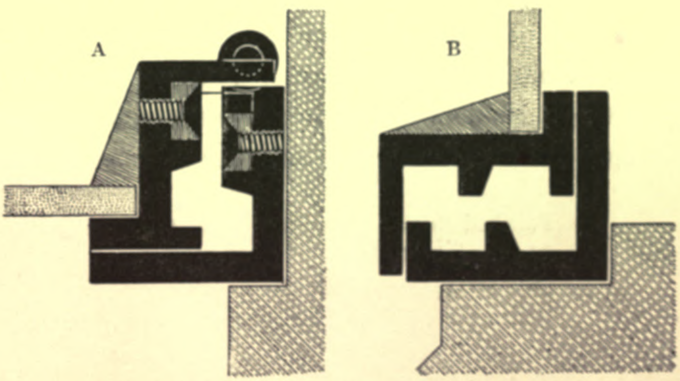


Fig. 95.—Wrought-iron Casement and Frame.

A, horizontal section of casement and jamb; B, vertical section of casement and sill.

Mention has already been made of the coldness of windows in winter, and of the improvement in this respect which may be gained by means of **double windows**, or **double panes of glass** with a small air-space between. Both devices reduce the sound transmitted through the windows, and this is certainly a great blessing in towns. When double windows are used, the outer window may be a sash-window, and the inner one a casement (generally hung folding and opening inward). Double panes are, however, a better protection against changes of temperature: Péclet's tests showed that, counting the loss of heat through a single sheet of glass as 1, the loss through two sheets 2·8 inches apart is ·6, 2 inches apart ·55, and ·8 of an inch apart only ·47. The construction of windows to receive double sheets of glass presents little or no difficulty; the wood must simply be rebated on both sides, and the outer sheet may be secured with putty in the usual way, while the inner may be kept in position by a small bead sprigged to the framing.

Glass is a very important part of a window. It is a comprehensive term, including sheet-glass, rough and polished plate-glass, patent rolled plate-glass in a great variety of tints and patterns, ground and obscured glass, enamelled sheet- and plate-glass, &c. Polished plate-glass is undoubtedly the best for most purposes, the most common thickness for ordinary house-windows being $\frac{1}{4}$-inch. Sheet-glass is of various qualities, and is sorted into thicknesses, usually known as 15-ounce, 21-ounce, 26-ounce, 32-ounce, and 36-ounce. The kind of glass to be used in any window or borrowed light will depend on the purpose it has to serve. If the window is for prospect and abundance of light, then sheet-glass or (better) plate-glass must be used. If, however, the prospect is obnoxious, some other kind of glass is desirable, such as patent rolled plate or leaded lights. It must not be forgotten, however, that every process which renders glass less clear to the eye, renders it also less transparent to light. Sir Douglas Galton gives the following results of experiments:—

Polished British plate-glass, $\frac{1}{4}$-inch thick,	intercepted	13	per cent	of the light.
36-ounce sheet-glass[1]	,,	22	,,	,,
Cast plate-glass, $\frac{1}{4}$-inch thick,	,,	30	,,	,,
Rolled plate-glass,[2] 4 corrugations in an inch,	,,	53	,,	,,

These figures may be supplemented by others[3] dealing with coloured glass as well as with plain:—

[1] This would be about $\frac{1}{8}$-inch thick. G. L. S.
[2] This would be about $\frac{1}{8}$-inch thick. G. L. S.
[3] From *Praktischen Gewerbehygiene*, edited by Dr. H. Albrecht. Berlin, 1896.

Ordinary window glass intercepted		4	per cent of the light.	
Double and crown glass	„	9–13	„	„
Plate-glass	„	6–10	„	„
Ground glass	„	30–66	„	„
Green and red glass	„	80–90	„	„
Orange glass	„	34	„	„
Opal glass	„	35–75	„	„

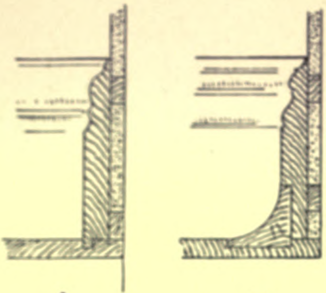
Doubtless the green and red colours were very strong. The "ordinary window glass" must have been extremely thin; it would have been better if the thickness of the glass had been given in each case.

2. *DOORS.*

Doors in houses are not generally of elaborate or peculiar construction, and do not therefore call for much notice. External doors should be made of good red deal or of one of the hardwoods—oak, mahogany, &c.; internal doors are sometimes made of pine, but red deal framing is better, with panels perhaps of pine, canary wood, or Californian redwood. Pitch-pine is so liable to shrink and warp that it cannot be recommended. The usual hardwoods are of course the most beautiful and durable, but their cost is often prohibitory. Undercut moulds around the panels should be avoided, on account of the difficulty of cleaning them; indeed a special panel for hospital doors has recently been designed, in which every angle and corner is rounded to prevent the lodgment of dust and germs and to facilitate cleansing. Where the ventilation of the house has been duly considered, draught-excluders, which largely prevent the entrance of dust, may with advantage be fixed on all external doors. A feature of internal doorways, which ought to be more frequently adopted for purposes of ventilation, is the hinged overlight, made to open and close at will; examples of these are given in Plate II. For large mansions, fire-resisting doors may be necessary in different parts of the building; these may be of wrought-iron or steel, or (better) of two or three thickness of wood boards covered with thin sheet metal.

3. *SKIRTINGS, PLINTHS, &c.*

Skirtings are usually of wood, moulded on the top edge, and fixed to form a sort of base or plinth to internal walls. As a rule, they are nailed either directly to plugs driven into the wall, or to wood grounds nailed to these plugs; the latter is the better arrangement. Frequently wood skirtings shrink after being fixed, and a wide open joint appears between them and the floors, forming a most insanitary harbour for dirt and vermin. In order to prevent this, the floor-boards should be ploughed to receive the skirting, as shown at A in fig. 96. A better form of wood skirting is given at B; the hollow member at the bottom does away with the dirt-collecting right-angle between floor and wall, and at the same time prevents chairs being placed so close to the wall as to damage the wall above by their backs. The first coat of the plaster on the walls should be continued quite down to the floor before the skirting is fixed.



A B

Fig. 96.—Wood Skirtings.

Cement skirtings are more expensive than wood and are somewhat apt to chip, but they are hygienically much more satisfactory, as they afford no hiding-place for vermin and do not decay. They may be of Portland cement or of plaster of Paris, or one of the varieties of this material,—Parian, Keene's, Martin's, and Robinson's cements.

Glazed bricks and tiles are excellent materials for plinths. Examples are given in fig. 27 page 81, fig. 47 page 105, and in Plate II.

Wainscot or wall-boarding is a wooden casing or lining to walls, and may be formed with tongued-and-grooved or rebated boards (usually with beaded or V-shaped joints), with a moulded top-rail, or may consist of more or less elaborate panelled and moulded framing with moulded plinth and capping. In either case, wood grounds are fixed to the walls to receive the wainscot. To prevent draughts and dirt, one coat of plasterer's "rough stuff" may be applied to the walls after the grounds are fixed, but this must be thoroughly dry before the wainscot is put up, or the wood may swell and twist; an additional precaution consists in painting the back of the wainscot before fixing it.

Chair-rails are narrow pieces of wood, usually moulded, fixed to walls at the height of the top of a chair-back to prevent the chairs damaging the walls. Sometimes they are grooved on the top, so that plates, photographs, &c., can safely be placed thereon. The groove, however, should be wide, or it is difficult to keep clean.

Picture-rails are the modern substitutes for the picture-rods of our fathers. They are shown in Plates II., III., and V. They are simply moulded pieces of wood nailed to plugs driven into the walls, and having a groove in the upper surface to receive picture-hooks. This groove undoubtedly collects dust, although this disadvantage may be modified by forming it in the lower part of the rail, instead of on the top as usual.

4. *STAIRS.*

Stairs in houses are generally of wood, framed together, but occasionally solid steps of oak are used after the manner of stone steps. Solid wood steps are more durable and offer greater resistance to fire than do the ordinary framed wood steps. Stone steps are cold to the touch, and apt to snap or disintegrate under the action of fire. The same remarks apply to concrete steps, although the fire-resistance of these may be improved by using a suitable aggregate, and by bedding in the concrete a meshwork of iron or steel in the form of rods, bars, expanded metal, &c. The height of the riser should be proportioned to the breadth of the tread, the following being a good rule:—Breadth of tread + twice the height of riser = 2 feet. It is not customary, however, to have risers less than five inches or more than nine inches. Turnsteps or winders are a source of danger; so also are odd steps in unexpected places. Dark staircases are very objectionable.

CHAPTER X.

PLASTER, WALL-TILES, &c.

Plaster is the popular name for the ordinary covering of lime and sand applied to internal walls. Technically, the word "plaster" often signifies plaster of Paris. Ordinary plaster consists of slaked lime and sand. The lime is a "fat" lime, devoid of hydraulic properties, and slaked by being mixed with a large quantity of water and allowed to stand in a "pit" for some weeks,—the longer the better. The sand should be free from clay, soot, organic matter, and other impurities, and must be washed before being used if these are present. Sea-sand must be avoided, as the salt in it has a great affinity for moisture. "Two-coat" work consists of a first coat of *coarse stuff*—*i.e.* slaked lime and sand mixed in the proportion of about one to three, a little cow-hair being usually added to bind the mixture together,—and a second and much thinner coat of *fine stuff* which contains only a little sand. "Three-coat" work ensures a truer and better surface, and consists of a first or "rendering" coat, a second or "floating" coat, and a third or "setting" coat. The last coat may be finished either with a wooden float or a steel trowel, the latter giving the smoother surface.

On ceilings and wood partitions, it is necessary to provide a backing, to which the plaster will adhere. This is usually formed with **laths** of oak or fir about an inch wide, and nailed to the studs or ceiling-joists about a quarter of an inch apart. Single laths are about $\frac{3}{16}$-inch thick, lath-and-half $\frac{1}{4}$-inch, and double laths $\frac{3}{8}$-inch. More fire-resisting substitutes for wood laths may be obtained in the form of Johnson's metal lathing, Banks's "Helical" metal lathing, and the "Expanded" metal lathing, all of which have been severely tested in actual fires. Another form of metal lathing is the "Jhilmil", but this contains much more metal than any of the others.

Ordinary plaster is undoubtedly porous, and absorbs both moisture and organic matter. Sir Douglas Galton says that "in a discussion, in 1862, in the French Academy of Medicine, a case was mentioned in which an analysis has been made of the plaster of a hospital wall, and 46 per cent of organic matter was found in the plaster". This is scarcely credible, but undoubtedly contamination by organic impurities given off by the lungs and skin does take place, and may prove a source of discomfort and ill-health. A harder and more impervious wall-covering may be obtained by using either **Portland cement,** or one of the so-called "cements" which have **plaster of Paris** for their base,—Martin's, Keene's, Parian, and Robinson's cements. These have the further advantage that they set at once and can be painted in a few hours after being laid, whereas ordinary plaster frequently takes weeks to harden, and cannot be satisfactorily painted for months.

The danger of occupying newly-plastered houses is a very real one, and it would be a blessing if sanitary authorities were careful to withhold certificates as to the suitability of houses for occupation, until the walls were thoroughly dry. Dr. Richardson has said: "I once visited a new and pretty row of houses in a London suburb to see a young lady there who was suffering from pulmonary consumption. The house was literally saturated with moisture. This patient died from the disease that had been lighted into activity there. On making further inquiries, I found that in the same row of houses, twenty in number, there occurred within the first two years of their occupation six other instances of pulmonary consumption and fourteen instances of acute rheumatic fever." Here is the case of another lady,—a confirmed cripple from rheumatic disease following upon acute rheumatic fever. "Newly married, she and her husband bought a new house, which, in their desire to settle quickly, they inhabited while the walls were still bedewed with moisture. She sickened with acute rheumatic fever, and never fully recovered from its effects. Worse than all, every one of her children—and she gave birth to seven after her attack—were affected with rheumatic disease, three dying from heart affection dependent upon the rheumatic constitution." Before occupying a new house, fires should be constantly maintained in all the rooms for several weeks, and streams of air should be passed through the rooms, by keeping all windows and internal doors constantly open, whenever the weather permits. Sunshine and change of air are powerful aids to dryness; indeed, without change of air, fires will be of little service. If the bricks and stone, of which the house was built, were thoroughly soaked with moisture before the plaster was applied, drying may be a question not of weeks but of months.

Plaster moulds and enrichments are often receptive of dust and difficult to clean, but undoubtedly a great change for the better is now taking place in this respect. The days of deep hollows in cornices, and of "bold" enrichments, appear to be numbered, and taste has reverted to the more refined detail of a century or two ago. A simple but effective cornice, without any dirt-catching members, was illustrated in fig. 76, page 135, and others are shown in Plates III. and V. The proper treatment of plaster lies undoubtedly in elaboration of surface, and not in constructing massive beams and ornament in high relief.

Fibrous plaster has a plaster face on a canvas backing, and can be obtained in plain slabs of various sizes, which are simply fixed to the wood ceiling-joists or studs by screws. A thin coat of plaster of Paris, applied to the whole, covers the joints and renders the surface uniform. A great saving of time is effected by the use of fibrous plaster slabs, and the house can be safely occupied much sooner than when ordinary plaster, or even cement, is used. Ornamental fibrous-plaster slabs are now made in endless variety to architects' designs, and are fixed to form the ceilings and friezes of important rooms.

Glazed wall-tiles are now largely used in bath-rooms, lavatories, water-closets, sculleries, pantries, vestibules and halls, &c.; they are made in numerous plain colours, or decorated and embossed in a variety of ways, the more expensive tiles being hand-painted. They are laid on walls on a bed of quick-setting cement, the joints of the brickwork being first raked out to afford a key for the cement. The backs of the tiles have sometimes undercut recesses, which, when the tiles are pressed into the wet cement, obtain a firm hold, and prevent the tiles falling off. Wood partitions, on which tiles have to be laid, may first be boarded, and the tiles fixed by brass-headed screws at the corners, each screw-head catching the corners of four tiles. Special tiles, however, have been devised, which dispense with these visible screws. Fig. 97 illustrates Hall's new improved patent hanging-tiles, fixed to wood battens by nails or screws passing through the holes c c. The two nails in each tile are covered by the tiles in the course above. When these tiles are used for walls, they are bedded on neat Portland cement, and firmly secured by pressing the tile against the wet cement, so that some of the cement passes through the splayed holes at A A, forming a dove-tail key. The tiles are made in stretchers ($9'' \times 2\frac{7}{8}''$ on face),

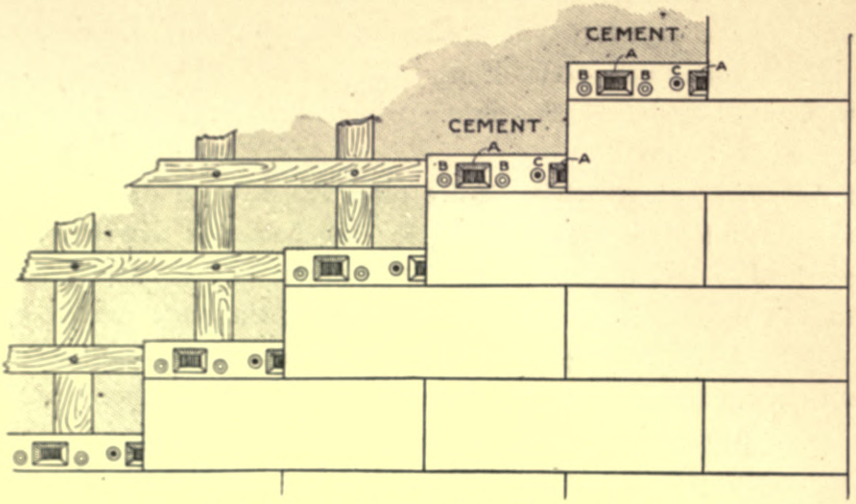


Fig. 97.—Hall's New Improved Patent Hanging-tiles.

headers ($4\frac{1}{2}'' \times 2\frac{7}{8}''$ on face), and in square and bull-nosed quoins; tiles $6'' \times 6''$ on the face are also made.

A new material, named "Opalite", has recently been introduced for wall-surfaces. It is a glazed plate, about one-sixteenth of an inch thick, and can be attached to walls after the manner of tiles. The plates need careful bedding, or cracks will be sure to occur sooner or later.

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